Hubris, Learning, and M&A Decisions

by

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Abstract

Are CEOs unable to learn? This surprising question deserves to be raised in the light of the declining pattern of cumulative abnormal returns observed in M&A programs. This paper shows that this pattern is the expected ex post empirical evidence for rational risk averse CEOs. Our theoretical argument is that from deal to deal, rational CEOs become more aggressive in the bidding process. They concede increasing fractions of expected synergies to the target shareholders in order to win the bidding game. For CEOs infected by hubris, the learning process should allow them to progressively correct over-optimism and overconfidence, if they survive.

It is widely recognized that the Chief Executive Officer (CEO) plays a central role in the merger and acquisition (M&A) decision process (see, e.g. Roll, 1986; Shleifer and Vishny, 1988). This central role has been relied upon for the empirical exploration of CEO behavior (e.g., overconfidence), CEO turnover, corporate governance mechanisms, and the effect of various entrenchment devices (e.g., Shleifer and Vishny, 1989; Mitchell and Lehn, 1990; Datta *et al.*, 2001; Malmendier and Tate, 2004; Zhao and Lehn, 2003). However, the CEO's role has attracted less attention in the theoretical literature.

Roll (1986) analyses the combined effects of CEO hubris and the *winner's curse* on observed mergers and acquisitions. Another important contribution is by Jensen (1986), who introduces the free cash-flow theory to explain CEO behavior in value-destroying acquisitions. The author shows that the market for corporate control (see, Manne, 1965) is an external corporate governance mechanism that helps alleviating the agency conflicts between managers and shareholders. In the same spirit, Shleifer and Vishny (1988; 1989) appraise the acquisition process from the managerial perspective. The authors emphasize entrenchment, showing how managers can reduce the probability of being replaced, extract higher wages and more perquisites from shareholders, and obtain greater latitude in determining corporate strategy. More recently, Malmendier and Tate (2004) explore both theoretically and empirically the CEO overconfidence hypothesis.

Our work, as that of Malmendier and Tate (2004), starts with Roll (1986). We develop a rational expectations model of the CEO M&A decision process under

uncertainty. Our CEO is risk-averse and under-diversified.[1] He has to choose a bid price for the target taking into account the probability of the deal going through (which depends on the prices offered by competitor bidders) and the probability of being fired (e.g., by shareholders angry about overpayment). Our results rely on ex ante expected utility maximization by the CEO. This is a key departure from previous work and it leads to new implications. Since our focus is on decisions made by individual CEOs, we hold constant the intensity of competition within the market for corporate control and the pressure of corporate governance mechanisms.

Modeling the random nature of CEO compensation within a framework of repeated acquisitions allows us to analyze how hubris and learning affect a CEO's M&A decision making. The repeated acquisition framework has been well document in the literature (e.g., Schipper and Thompson, 1983; Asquith *et al.*, 1983; Malatesta and Thompson, 1985; Fuller *et al.*, 2002). Further, the empirical results of Rosen (2004) clearly show the interaction between acquisition programs and CEO compensation.

Bernardo and Chowdhry (2001) point out that learning is fundamentally at the heart of the firm behavior, both at the organizational and at the individual level. However, Conn *et al.* (2004) and Bradley and Sundaram (2004) seem to find evidence against the importance of learning. The former authors use a large sample of 4.000 British M&As from 1984 through 1998. They conclude that "declining impacts associated with later sequence order (of M&A operation) is inconsistent with a learning hypothesis". Similarly, Bradley and Sundaram (2004) conclude that "we also find no evidence of any gains to learning-by-doing". We do not question the observed declining pattern of

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[1] Several articles document that CEOs' personal portfolios are inherently under-diversified. Their physical and human capital is invested disproportionately in their company (e.g., Hall and Murphy, 2002; Malmendier and Tate, 2004).

abnormal returns from deal to deal (also reported by Fuller *et al.* (2002) and Rosen (2004)). However, we argue that the pattern is entirely consistent with learning. Indeed, is it really plausible that CEOs suffer from a learning disability when it comes down to M&A decisions? Our theoretical analysis shows that a decline in abnormal returns in successive acquisitions is not only compatible with learning, but it is the pattern that should be observed when rational CEOs are learning.

It is also worth mentioning that we focus on the impact of hubris and learning during the M&A decision process (choosing the best targets, synergies evaluation, bid negotiation,…) and not on the ability of the management to learn during the ex-post integration process (as in Leshchinskii and Zollo, 2004), with the exception of anticipated synergies.

In our model, two opposing forces reflecting the CEO's fundamental tradeoff are at play. In trying to increase the probability of a successful deal, the CEO is tempted to increase the bid price. However, this action could lead to a higher probability of getting fired as the result of a (perceived) overpayment. Once both hubris and learning are permitted, we obtain the following implications:[2]

- the optimal takeover premium is a negative function of the volatility of expected synergies (volatility increases the uncertainty about the deal's true value) and of the correlation coefficient between the current profits of the target and expected synergies (the higher this correlation, the higher the CEO's personal under-diversification);

- hubris, captured as overconfidence (i.e. a systematic overestimation of the potential synergies, see Baker *et al.*, 2005), leads to an increase in the optimal

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[2] The results are stated in terms of optimal premium offered to the target shareholders.

premium and, not surprisingly, to overpayment. However, an exception occurs when the CEO earns a high risk-adjusted bonus; this could engender more conservatism. Over-optimism, which is defined in our setting as a systematic underestimation of the synergy risk, leads unambiguously to overpayment;

- for rational CEOs, learning improves their forecasting ability, which in turn decreases the (perceived) variance of expected synergies. Therefore, learning will lead to an increase in the optimal premium, a higher probability of deal success (and to be observed ex-post), the concession of a higher proportion of expected synergies to the target shareholders and lower ex-post bidder abnormal returns;

- for CEOs infected by hubris, the consequences of learning should be a progressive correction of the cognitive biases. The frequency of deal completion should decrease but, from deal to deal, the value destruction should also be decreasing.

The analysis of interactions between the optimal premium, the probability of deal completion, the probability of being fired and the ex-post observed abnormal returns delivers interesting insights on ex-post testable hypotheses. On one hand, a higher optimal premium will lead to a higher probability of deal completion, and thus to a higher probability of being included in the ex-post observable sample of M&A deals. This corresponds to the *winner's curse* sample selection bias identified by Roll (1986). On the other hand, a higher optimal premium could also increase the probability of being fired, which brings up a second sample selection problem (we label it the survival bias). These are opposing biases; which one dominates is an open empirical question. Researchers should take them into account when designing and interpreting empirical tests.

The paper is organized into sections as follows. Section 1 presents the fundamental CEO tradeoff. Section 2 introduces random state dependent CEO compensation, hubris and learning. Section 3 explores the model behavior, and puts forward its main implications. Section 4 concludes.

1. The CEO Decision Problem

By choosing a bid price, the CEO determines both the probability of the takeover being successful (defeating the best competitors' offer) and the probability of being fired (due to overpayment). The framework that we develop in this first section ignores the effects of hubris and learning and assumes a strictly rational CEO. This stylized model allows us to clearly state the CEO's decision problem.

1.1 Initial setup and notations

In contrast to Shleifer and Vishny (2003), we assume that the capital markets are efficient. Consequently, the market price delivers an unbiased estimate of the firms' true economic value and M&As are not motivated by over or under-evaluation opportunities.[3] In this initial framework, the strictly rational CEO determines a bid price for a selected target. Depending on this price, three outcomes are possible (see Figure 1):

- **No Deal:** a competitors' best price is higher than the one proposed by the CEO or the target firm successfully rebuffs the bid;

- **Deal and CEO Retention:** the proposed bid price allows the CEO to succeed in the deal and avoid being fired;

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[3] This assumption has an implicit corollary that the auction process itself does not reveal information about the real value of the target.

- **Deal and CEO Dismissal**: the deal is successful; however the CEO is fired. Bidder shareholders (or some other controlling mechanism such as the market for corporate control) do not accept the value destruction resulting from overpayment. As shown in Jensen (1986), Mitchell and Lehn (1990), Zhao and Lehn (2003), Kini *et al.* (2004), this corresponds to a real risk in practice.

When determining a bid price, the CEO takes into account the probability of the above potential outcomes as well as the expected compensation in each case.

Let us adopt the following notation:

- MV_T is the market value of the target, which we normalize to one;

- P is the bid price and the corresponding bid premium is $\pi = P - MV_T = P - 1$;

- $\varphi_S(\pi)$ is the probability of a successful deal and $\varphi_F(\pi)$ is the probability of being fired. Both probabilities depend on the bid premium π (for the remainder of the paper, we suppress the functional dependence on π in order to simplify the notation);

- we use L, B and W to define the CEO compensation contract, where W is the value of his current contract (the present value of the future cash flows stemming from existing activities); B is the bonus in case of deal completion, and L denotes the loss in the event of dismissal. W, B and L are, in this first section, assumed to be known positive constants.

This specification of the CEO compensation contract is in line with the existing literature. For example, Hall and Liebman (1998) argue that CEOs are not paid like bureaucrats, since there is a strong relationship between firm performance and CEO compensation. During the 90s, equity-based compensation, which relates CEO

remuneration to expected profits, has become the single largest source of income for US executives (see, e.g., Datta *et al.*, 2001, Hall and Murphy, 2002; Malmendier and Tate, 2004). Moreover, bonuses received by CEOs are significant after successful deal completions (see Grinstein and Hribar, 2004).

The two opposing forces at play in the CEO's decision problem give rise to the following conditions on the relationship between the probabilities (φ_S and φ_F) and the bid premium (π):

- $\varphi_S' \equiv \dfrac{\partial \varphi_S}{\partial \pi} > 0$: the probability of a successful deal increases with the bid price;

- $\varphi_F' \equiv \dfrac{\partial \varphi_S}{\partial \pi} > 0$: the probability of dismissal increases with the bid price.

1.2 The CEO decision problem

The expected utility of the CEO is given by:

$$E(U) = (1 - \varphi_S)U(W) + \varphi_S(1 - \varphi_F)U(W + B) + \varphi_S\varphi_F U(W - L), \tag{1}$$

where $U(.)$ denotes the utility function, which can be approximated by an order two Taylor development around W. We obtain the following expressions:

$$U(W - L) = U(W) - LU'(W) + \frac{1}{2}L^2 U''(W); \tag{2}$$

$$U(W + B) = U(W) + BU'(W) + \frac{1}{2}B^2 U''(W). \tag{3}$$

Substituting Equations (2) and (3) into Equation (1) yields:

$$E(U) = U(W) + \varphi_S \left[\left[(1 - \varphi_F)B - \varphi_F L \right] U'(W) + \left[\varphi_F \frac{L^2}{2} + (1 - \varphi_F)\frac{B^2}{2} \right] U''(W) \right]. \tag{4}$$

The CEO choose π to maximize expected utility, which leads to the following first order condition:

$$\left[\varphi_S{}'-(\varphi_S\varphi_F)'\right]B-(\varphi_S\varphi_F)'L-\gamma\left[\{\varphi_S{}'-(\varphi_S\varphi_F)'\}\frac{B^2}{2}+(\varphi_S\varphi_F)'\frac{L^2}{2}\right]=0\,, \tag{5}$$

where γ is the classical absolute risk aversion coefficient $-U''(W)/U'(W)$. This result takes explicit account of the CEO's risk aversion, which Becker (forthcoming *Journal of Finance*) has recently shown to be empirically important.

1.3 Uncertainty specification

In order to derive a closed form solution for the optimal premium, π^*, we need to specify the probabilities φ_S and φ_F. We use Uniform probability distributions, which simplify the analysis while allowing us to capture the essential features of the CEO's decision problem.

The probability of success φ_S

Financial markets set the value of the target (MV_T) which defines the minimum bid price in order for the takeover to have any chance of being successful. The existence of a minimum admissible price is an essential dimension of the market for corporate control. This minimum price also provides us with a natural lower bound for φ_S since at that price a bid will fail: if $P = MV_T$ (or $\pi = 0$ taking into account the definition of π and the normalization of MV_T to 1), φ_S is equal to zero.

Furthermore, we assume that:

- there is a maximum bid price (θMV_T or simply θ under the normalization) at which the CEO is certain to make the deal. This price is such that any competing offer will be defeated;

- φ_S has a uniform density function on a support (π) bounded by 0 and $\theta - 1$.

For a given π, the probability of success is therefore $\varphi_S = \pi/(\theta - 1)$. Note that, as required in Section 1.1, $\varphi_S{}'$ is positive: the higher the bid premium, the higher the probability of a successful deal. Given that θ is an exogenous parameter, to further simplify the presentation we set it to 2.

The (conditional) probability of being fired φ_F

In case the CEO wins the auction, he risks being fired with a probability φ_F. The target market value, MV_T, again provides a natural lower bound. Indeed, if $P = MV_T$ (or $\pi = 0$), there is no reason for the CEO to be fired as the acquisition price is equal to the market value. Therefore, φ_F is equal to zero.

Furthermore, we assume that:

- if the CEO wins the auction by offering the maximum conceivable price ($\pi = \theta - 1$ or $\pi = 1$ under our normalization) he is fired with probability one;

- φ_F has a uniform density function on a support (π) bounded by 0 and 1.

The probability of being fired is therefore $\varphi_F = \pi$. Note again that, as required in Section 1.1., $\varphi_F{}'$ is positive: the higher the bid premium, the higher the probability of being fired.

The (unconditional) probabilities

The probabilities missing out on the deal, doing the deal and not being fired and doing the deal and being fired are respectively (see Figure 1) $(1 - \varphi_S)$, $\varphi_S(1 - \varphi_F)$ and $\varphi_S\varphi_F$.

- $(1 - \varphi_S) = 1 - \pi$, the probability of missing out on the deal decreases linearly as π increases (see Figure 2, Panel A);

- $(\varphi_S(1-\varphi_F)) = \pi(1-\pi)$, the probability doing the deal and not being fired is a concave function (see Figure 2, Panel B). When π is close to 0 (no premium is proposed), increasing π has a strong impact on the probability of doing the deal and not being fired. As π is still low, the impact on the probability of being fired is marginally low. When π is high, the probability of doing the deal (the sum of $(\varphi_S\varphi_F)$ and $\varphi_S(1-\varphi_F)$ increases but it is the probability of being fired that eventually dominates;

- $(\varphi_S\varphi_F) = \pi^2$, the probability of being fired (knowing that the CEO has won the bidding game) is convex (see Figure 2, Panel C). For high π the increase in the probability of being fired becomes significant. This captures the intuition that the corporate governance system comes into play as a last resort mechanism. The CEO is exposed significantly to the risk of being fired only when the deal brings massive wealth destruction for bidder shareholders.

1.4 Optimal premium

Solving for the CEO's first order condition (Equation (5)) by using the specification of the previous section for φ_S and φ_F, we obtain π^*, the optimal premium:

$$\pi^* = \frac{1}{2} \frac{\left(B - \frac{\gamma}{2}B^2\right)}{\left((B - \frac{\gamma}{2}B^2) + (L + \frac{\gamma}{2}L^2)\right)}. \tag{6}$$

This closed form solution is pivotal in order to analyze the effect of hubris and learning on the CEO decision process in Section 2. Notice that $(B - (\gamma B^2/2))$ is the risk adjusted bonus and that $(L + (\gamma L^2/2))$ corresponds to the risk adjusted loss (L being a loss, it enters negatively into the CEO utility function). The probabilities (φ_S and φ_F)

derived from the solution must be positive. From the previous section we know that $\varphi_S = \varphi_F = \pi$, implying that π^* is between 0 and 1, which in turn leads to constraints on the set of admissible values for B and L. An easy way to pinpoint these constraints is to set L equal to zero (implying no loss in case of dismissal). Under this assumption, Equation (6) leads to π^* equals to 1/2. This is an intuitive result since the chosen premium is the one that maximizes the probability of a successful takeover and of not being fired (see Figure 2 – Panel B). If L is positive (which it is by assumption in our model), the optimal premium must therefore lay at the left of 1/2 (see Figure 3). In this zone, the derivative of $\varphi_S (1 - \varphi_F)$ with respect to π^* is positive. Computing this derivative and taking into account its positive sign constraint leads to a positive risk adjusted bonus $(B - (\gamma B^2 / 2))$.

2. Hubris and Learning

Behavioral corporate finance is an active research field during the last two decades. Baker *et al.* (2005) identify two broad approaches, depending on the (ir)rationality assumptions about investors (a typical example is Shleifer and Vishny (2003)) and/or managers. In this section we focus on less than fully rational CEOs, whose judgmental biases stem from three interrelated phenomena:

- They do not possess a perfect knowledge of the state of the world parameters' distribution;

- Their estimations may be affected by over-optimism and/or overconfidence;

- They are able to learn from past experience.

Cognitive biases may come into play at two levels: the perception of the probabilities of a successful deal (φ_S) and, conditionally on a success, the probability of being fired (φ_F) and/or the perception of the state dependent CEO compensation (*W, L* and *B*). We focus here on the latter. Analyzing the impact of learning on φ_S and φ_F would require explicitly modeling the bidder competitors' behavior. While being an interesting direction for future research, it is beyond the scope of this paper.

In order to reflect the CEO's imperfect knowledge of his state dependent compensation, we need to depart from the previously-assumed current constant specification and introduce randomness. This is done in Section 2.1. Cognitive biases and learning are only relevant if the CEO's perception of state probabilities are not in line with the true distribution. Section 2.2 considers this issue. Section 2.3 introduces hubris as either overconfidence (see Malmendier and Tate, 2004) or over-optimism. Section 2.4 builds on known results of Bayesian analysis to depict the impact of learning. Finally, Section 2.5 derives the explicit optimal bid price (premium) chosen by the CEO.

2.1. Random State Dependent CEO Compensation

As in Section 1, P denotes the chosen bid price, π the bid premium, φ_S the probability of success and φ_F the probability of being fired conditionally on doing the deal. The assumption of a constant compensation (the bonus B and the firing loss L) in each state of the world is relaxed. Instead, they now become functions of two random variables, the profit generated by the current business operations of the target (τ) and the synergies between the target and the acquirer (s), as follows:

- **No Deal**: in case of a failed deal, as in Section 1, the CEO receives a fixed compensation W. This implicitly assumes that the CEO knows his future

compensation from continuing the firm's current activities. Allowing for a random W does not change our conclusions and would needlessly complicate the exposition;

- **Deal and CEO Retention**: in addition to W, the CEO receives a bonus $B = b(\tau + s)$, where b is a constant;

- **Deal and CEO Dismissal**: if the CEO is fired, his compensation amounts to $W - L$, where L is a random loss due to his negative performance. Implicitly, when the deal is value-destroying, the CEO is dismissed prior to earning the full salary W.

In summary, the CEO's compensation is W if the deal fails (probability $(1 - \varphi_S)$), $W + b(\tau + s)$ if the deal is successful and he is not fired (probability $\varphi_S(1 - \varphi_F)$) and $W - L$ if he is dismissed (probability $\varphi_S \varphi_F$). We assume that τ, s and L follow Gaussian distributions ($\tau \sim N(\mu_\tau, \sigma_\tau^2)$, $s \sim N(\mu_s, \sigma_s^2)$ and $L \sim N(\mu_L, \sigma_L^2)$). The specification of φ_S and φ_F remains the same as in Section 1.

Conditional on deal completion, the expected CEO bonus and its variance are, respectively,

$$\mu_B = b(\mu_\tau + \mu_s);\tag{7}$$

$$\sigma_B^2 = b^2(\sigma_\tau^2 + \sigma_s^2 + 2\sigma_{\tau,s}).\tag{8}$$

The volatility of the CEO's conditional compensation depends on the variance of both current target activities and of anticipated synergies and also on their covariance. Because of the this covariance, we are able to model the potential effect of a diversifying acquisition on the CEO's decision.

2.2. CEO perceptions

We now leave the strict rational anticipations framework by assuming that the CEO does not know the true μ_s (the expectation of the anticipated synergies) and σ_s^2 (its variance) but rather tries to estimate them. We denote the current estimates $\hat{\mu}_{s,t}$ and $\hat{\sigma}_{s,t}^2$, where t represents the "present time" (or the "current acquisition") and $\hat{\mu}_{s,t-1}$ and $\hat{\sigma}_{s,t-1}^2$ refers to the prior estimation.

The CEO interprets market reactions to previous deal announcements as revealing information about his capacity to generate value through M&A operations (quality of target selection, negotiation of deal terms, realization of the anticipated synergies, …). This conforms to the notion of efficient capital markets. Luo (forthcoming *Journal of Finance*) shows clearly that CEOs learn from market reactions around deal announcement dates and that such reactions influence their willingness to complete the deal. The signal is noted *v* and takes the following form:

$$v_i \sim N(\mu_s, \sigma_v^2). \tag{9}$$

The expectation of *v* is the expected anticipated synergies (in percentage of the market value of the target): the signal delivers information about the CEO's ability to uncover targets that are likely to generate positive synergies. The variance of the signal σ_v^2 is a measure of the informativeness of market feedbacks. Notice that signals are centered on μ_s, the population parameter, and therefore convey information about the *real* synergies expectation.

2.3. Hubris

Several articles provide empirical evidence supporting hubris as a trait of CEOs' behavior (e.g., Rau and Vermaelen (1998), Moeller *et al.* (forthcoming *Journal of*

Finance), Malmendier and Tate (2004)). In the spirit of Malmendier and Tate (2004), we introduce hubris as a cognitive bias in the CEO decision making process. Depending on how pessimistically we perceive human nature, hubris may either affect the CEO's initial perception (the anticipated synergy estimation at his first deal attempt), or his learning process (the interpretation of market reactions around previous successive deals) or even both. However, as our model predictions can only be tested ex-post on a sample of surviving CEOs, we assume that hubris affects (only or mainly) the CEO's initial perception. More explicitly, the CEO infected by hubris has a biased prior perception of potential synergies with the target. If after realizing the first operation he is not fired, he will learn. From deal to deal, this learning process will allow him to progressively correct his initial bias. This assumption most probably does not describe the behavior of all CEOs infected by hubris (notorious cases cited in the financial press do probably not allow such optimism …) but it seems reasonable to assume that CEOs infected by hubris will be fired at a higher rate than those who are able to correct erroneous initial assessments. Learning CEOs should have a higher survival rate.

The bias of the CEO's initial perception may affect both the *perceived* level of expected synergies with the target and its *perceived* variance. The CEO initial prior is therefore $\hat{s}_0 \sim N(h_\mu \hat{\mu}_{s,0}, h_\sigma \hat{\sigma}_{s,0})$, where *0* denotes the fact that $\hat{s}_0$ represents the CEO's perception before the first deal and h_μ and h_σ are hubris coefficients. In order to introduce hubris in this setting, either h_μ exceeds unity (synergies are over anticipated: the CEO is over-optimistic) and/or h_σ is less than unity (the risk associated with synergies anticipation is understated: the CEO is overconfident).

2.4. Learning

Learning has long been recognized as an important determinant of decisions. Firms learn about the environment in which they operate (e.g., Prescott, 1972; Grossman *et al.*, 1977, Zeira, 1987; Rob, 1991; Berk *et al.*, 2004) or about themselves (e.g., Jovanovic, 1982; Jovanovic and MacDonald, 1994; Bernardo and Chowdhry, 2002). Learning can be the result of innovation, imitation or experimentation.

Here, the focus will be on learning during the pre-bid phase. M&A is ideally suited for such an investigation since firms (and their CEOs) often undertake acquisition programs (Schipper and Thompson, 1983; Asquith, Bruner and Mullins, 1983; Malatesta and Thompson, 1985; Fuller *et al.*, 2002). M&A operations typically involve many resources, take time to prepare, negotiate and consummate and thus require an intense commitment by decision makers. If learning is a key trait of decisions maker behavior, it should profoundly influence the M&A decision process. As pointed out in the introduction, the Bradley and Sundaram (2004) empirical results are surprising. They are unable to find "any gains to learning-by-doing" (Bradley and Sundaram (2004), p. 6). Conn *et al.* (2004) report a comparable result in the U.K. context. Why should M&A decision-making be an exception to CEO learning? Could it be the result of misunderstanding the potential (ex-post observable) implications of learning? In order to shed some light on this apparent paradox, we introduce Bayesian learning.

Both the CEO's prior distribution and the market signals being Gaussian, we use classical Bayesian inference results to derive the CEO's current perceptions of anticipated synergies (the moments of his posterior distribution):

$$\hat{\mu}_{s,t} = \frac{\frac{1}{h_\sigma \hat{\sigma}_{s,0}^2} h_\mu \hat{\mu}_{s,0} + \frac{1}{\sigma_v^2} \sum_{i=1}^{t-1} v_i}{\frac{1}{h_\sigma \hat{\sigma}_{s,0}^2} + (t-1) \frac{1}{\sigma_v^2}};$$ (10)

$$\frac{1}{\hat{\sigma}_{s,t}^2} = \frac{1}{h_\sigma \hat{\sigma}_{s,0}^2} + (t-1) \frac{1}{\sigma_v^2},$$ (11)

where *(t-1)* is the number of signals (market reaction to previous deals) already received by the CEO in the past. Equation (10) shows that the expectation of the anticipated synergies is a function of the past experience. The higher the number of signals *(t-1)*, the closer will $\hat{\mu}_{s,t}$ be to μ_s, (as the market is efficient and delivers signals centered on the population parameter). The speed of convergence (measured by the variance of the posterior distribution in Equation (11)) depends on the precision of the information sent to the CEO (the inverse of the signal variance $1/\sigma_v^2$). Note that if σ_v^2 tends to infinity, the signal's precision goes toward zero. The posterior precision of the anticipated synergies $1/\hat{\sigma}_{s,t}^2$ is then equal to the prior one $1/\hat{\sigma}_{s,0}^2$ and the posterior expected value of the synergies $\hat{\mu}_{s,t}$ is equal to its prior $\hat{\mu}_{0,t}$. In this case, market information is just noise. Equations (10) and (11) shed light on the positive relation that should exist between market signal precision and the pace of decision makers learning. To the best of our knowledge, empirical validation of this connection remains to be established. Given that market signals are Gaussian (see Equation (9)) the posterior is also Gaussian ($\hat{s}_t \sim N(\hat{\mu}_{s,t}, \hat{\sigma}_{s,t}^2)$).

An important point that should not be overlooked is the implicit assumption of a constant investment opportunity set. Learning might (and probably does) affect not only the CEO's ability to anticipate synergies with precision but also the target selection

process. In this case, the investment opportunity set is evolving and real expected synergies (μ_s) might be changing from deal to deal; (intuitively, they should be increasing). This is not taken into account in Equations (10) and (11) which implicitly assume that μ_s is constant. When designing an empirical testing strategy to isolate the effect of learning, one should control for a possibly evolving investment opportunity set.

2.5. The CEO's Optimal Decision

When taking into account learning and hubris, the expectation and the variance of the CEO's bonus (Equations (7) and (8)) become, respectively:

$$\hat{\mu}_{B,t} = b\left(\mu_\tau + \left(\frac{\frac{1}{h_\sigma \hat{\sigma}_{s,0}^2} h_\mu \hat{\mu}_{s,0} + \frac{1}{\sigma_v^2} \sum_{i=1}^{t-1} v_i}{\frac{1}{h_\sigma \hat{\sigma}_{s,0}^2} + (t-1)\frac{1}{\sigma_v^2}}\right)\right); \tag{12}$$

$$\hat{\sigma}_{B,t}^2 = b^2\left(\sigma_\tau^2 + \left(\frac{1}{h_\sigma \hat{\sigma}_{s,0}^2} + (t-1)\frac{1}{\sigma_v^2}\right) + 2\sigma_{\tau,s}\right). \tag{13}$$

Equations (12) and (13) highlight how hubris and learning impact the CEO's perception of his future compensation. The CEO's expected utility is:

$$E(U) = (1 - \varphi_S)E(U(W)) + \varphi_S(1 - \varphi_F)E(U(B)) + \varphi_S \varphi_F E(U(L)). \tag{14}$$

Since W is a constant, $E(U(W)) = U(W)$. We approximate $E(U(W+B))$ and $E(U(W-L))$ by an order 2 Taylor development and derive the CEO's optimal decision:

$$\pi^* = \frac{1}{2} \frac{\hat{\mu}_{B,t} - \frac{\gamma}{2}(\hat{\mu}_{B,t})^2 - \frac{\gamma}{2}\hat{\sigma}_{B,t}^2}{\left(\hat{\mu}_{B,t} - \frac{\gamma}{2}(\hat{\mu}_{B,t})^2 - \frac{\gamma}{2}\hat{\sigma}_{B,t}^2\right) + \left(\mu_L + \frac{\gamma}{2}\mu_L^2 + \frac{\gamma}{2}\sigma_L^2\right)} \tag{15}$$

The structure of Equation (15) is strictly analogous to the one of Equation (6) (the optimal premium derived in Section 1). The risk-adjusted bonus is found at the numerator while the sum of the risk adjusted bonus and the risk adjusted penalty (caused by potential dismissal) is found at the denominator. It is worth mentioning that:

- the parameter space constraints are equivalent to those in Section 1. If L is set to zero, π^* equals 1/2. If L is positive, the optimal solution must lay at the left of this point (see Figure 3). For the same reason as in Section 1 (the derivative of $\varphi_S(1-\varphi_F)$ with respect to π is positive in this region), the risk adjusted bonus (the numerator of Equation (15)) must be positive. This in turn implies that $\hat{\mu}_{B,t} - (\gamma/2)(\hat{\mu}_{B,t})^2$ is positive and greater than $(\gamma/2)\hat{\sigma}_{B,t}^2$. This result will be helpful when analyzing the CEO's optimal behavior;

- it is also interesting to formally establish the link between the optimal premium and the observed bidder abnormal returns at the deal announcement. Considering that in our setup financial markets are efficient, the stock price reaction should be:

$$AR = \frac{\mu_s - P}{MV_B} = \frac{\mu_s - (\pi+1)}{MV_B}, \tag{16}$$

where μ_s reflects anticipated synergies by investors (which is equal to the population expectation in a rational expectation framework), and MV_B is the bidder's market value. Consequently, while the optimal premium is a positive function of the bid price, bidder abnormal returns are a negative function of it. Any conclusion about the optimal premium behavior also holds inverted for the abnormal return.

3. Model implications

Equation (15) gives us the optimal premium chosen by a risk averse CEO who is potentially infected by hubris but able to learn. This central result allows us to develop a better understanding of the ex-post empirical implications that should be observed if actual CEOs are susceptible to these influences. The preliminary step is to study the derivative of the optimal premium with respect to the (perceived) expected bonus and its variance. Using these results, we turn to the specific analysis of the implications of hubris and learning. We finally highlight other interesting implications of Equation (15).

3.1. Preliminary

Optimal premium rate derivative with respect to expected bonus

We are interested in the sign of $\partial \pi^* / \partial \hat{\mu}_{B,t}$. A mechanical application of calculus rules to Equation (15) shows that, assuming a positive $\hat{\mu}_{B,t}$[4], the sign of the derivative is set by the sign of $(1 - \gamma \hat{\mu}_{B,t})$. Moreover $(1 - \gamma \hat{\mu}_{B,t})$ is positive if $\hat{\mu}_{B,t} < 1/\gamma$. We also know from Section 2.5 that $\hat{\mu}_{B,t} - (\gamma/2)(\hat{\mu}_{B,t})^2$ must be greater than $(\gamma/2)\hat{\sigma}_{B,t}^2$. This second condition translates into $\hat{\mu}_{B,t} < (2/\gamma) - (\hat{\sigma}_{B,t}^2/\hat{\mu}_{B,t})$. These two conditions lead to the situation presented in Figure 4:

- for $\hat{\mu}_{B,t}$ between 0 and $1/\gamma$: $\partial \pi^* / \partial \hat{\mu}_{B,t}$ is positive. An increase in the expected bonus leads to an increase in the optimal premium rate. This is certainly plausible on an intuitive level. The optimal premium being a positive function of anticipated synergies, target abnormal returns are also a positive function of anticipated synergies. This result is consistent with the framework

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[4] This assumption is required to ensure positive probabilities for each potential outcome.

provided by Berkovitch and Narayanan (1993), in which synergistic M&A operations should lead to a positive correlation between target and bidder gain.

- for $\hat{\mu}_{B,t}$ between $1/\gamma$ and $(2/\gamma) - (\hat{\sigma}^2_{B,t}/\hat{\mu}_{B,t})$: the derivative is negative. This second situation might seem strange as an increase in the expected bonus could lead to a decrease in the optimal premium. Such a possibility is a consequence of the convexity of $\varphi_S \varphi_F$, depicted in Figure 2 – Panel C. A high expected bonus combined with a low bonus variance dramatically increases a CEO's loss in the event of dismissal. Rather than vigorously pursuing the deal, the CEO responds by reducing the risk of being fired. In short, he has more to loose than to win. Such behavior is consistent with (internal or external) corporate control mechanisms that become more pertinent after value destruction (the unconditional probability of dismissal is convex with respect to the premium).

- it is finally worth noting that, if $\hat{\sigma}_{B,t}/\hat{\mu}_{B,t}$ is greater than $1/\gamma$ (the risk of the expected bonus is high and/or its expectation is low), $\partial \pi^*/\partial \hat{\mu}_{B,t}$ is unambiguously positive.

Optimal premium derivative with respect to expected bonus variance

The sign of $\partial \pi^*/\partial \hat{\sigma}^2_{B,t}$ depends on the sign of the derivatives of $\hat{\mu}_{B,t} - (\gamma/2)(\hat{\mu}_{B,t})^2 - (\gamma/2)\hat{\sigma}^2_{B,t}$ with respect to $\hat{\sigma}^2_{B,t}$. The risk aversion coefficient (γ) being positive by definition, the sign of $\partial \pi^*/\partial \hat{\sigma}^2_{B,t}$ is negative. An increase in the (perceived) variance of the expected bonus leads to a decrease in the optimal premium.

Having established these two results, we can focus on the analysis of the implications of the CEO's optimal behavior.

3.2. Hubris implications

Hubris can take the form of over-optimism ($h_\mu > 1$) and/or overconfidence ($h_\sigma < 1$). As explained in Section 2.3, it affects the CEO's initial perceptions. Using the results of Section 3.1, the impact of hubris can be summarized as follows:

- overconfidence leads to an increase in the optimal premium, which will increase the probability of doing the deal (winning the auction). Since the premium is partly a distorted perception of reality, the market reaction will be negative (if capital markets are efficient). This is the first channel by which hubris leads to value destruction;

- over-optimism leads to the same consequences as over-confidence in deals for which the ratio $\hat{\sigma}_{B,t}/\hat{\mu}_{B,t}$ is high enough. An increase in the probability of doing the deal and negative ex-post observed cumulative abnormal returns (CAR). For CEOs with high expected bonus and low variance, over-optimism can lead to a conservative attitude (at least when corporate control mechanisms become tougher when value destruction increases). This leads in turn to a reduction in the probability of winning the auction;

The analysis of the optimal CEO behavior also sheds light on another important pitfall affecting ex-post analyses: sample selection biases. Roll (1986) describes the potential impact of *winner's curse* and hubris on the ex-post observed abnormal returns. Our analysis suggests a second sample selection phenomenon; viz., we do not observe

deals that would have been undertaken by dismissed CEOs. It is important to understand the consequences of the combined effects of these two biases:

- as explained in Roll (1986), hubris leads CEOs to overbid, so they are subject to the *winner's curse*. We observe only those who win the auction, so we most probably observe overconfident CEOs (or over-optimistic CEOs for deals with $\hat{\sigma}_{B,t} / \hat{\mu}_{B,t}$ high enough). Ex-post abnormal returns should be negative;

- the *survival bias* works in the opposite direction. Bad performing CEOs are fired and good ones survive. The probability of being fired is a countervailing force to hubris and to the *winner's curse* bias.

Which one of these two biases dominates? This is an empirical question. Its answer depends, *inter alia*, on the pressure of corporate control mechanisms (the convexity of $\varphi_S \varphi_F$ in our model) and on the strength of hubris (h_μ and h_σ).

3.3. Learning implications

Equation (15) and the analyses of Section 3.1, have implications concerning the pattern of stock prices around deals and the typical elapsed time between successive deals for rational and hubris infected CEOs. The logical consequences of our model are presented in Figure 5 – Panel A, B and C. The main conclusions are:

- for rational CEOs, the more the CEO learns, the more accurate his forecasting ability and the lower $\hat{\sigma}_{s,t}^2$ (see Equation (12)). A decrease in $\hat{\sigma}_{s,t}^2$ should therefore lead to an increase in the proposed price (more aggressive bidding behavior), an increase in the probability of doing the deal and a decrease in observed abnormal returns. This CAR time path (of the bidder) is displayed in Figure 5 – Panel A. Abnormal returns decrease from deal to deal. According to our model, the results

of Bradley and Sundaram (2004) and Conn *et al.* (2004) are perfectly compatible with learning. This decreasing trend of successive abnormal returns should be observed after controlling for the potential change of the investment opportunity set due to learning (see Section 2.4). Another implication of learning is that, everything else being held constant, we should observe a reduction in the average elapsed time between successive deals (see Figure 5 – Panel A – right chart). More aggressive bidding increases the probability of doing a deal.

- for hubris infected CEOs (either over-confident or over-optimistic, as long as the ratio $\hat{\sigma}_{B,t}/\hat{\mu}_{B,t}$ is high enough) value destruction should decrease from deal to deal, provided that corporate control mechanisms let them survive long enough to learn. As shown in Figure 5 – Panel B, the paths of the CAR and the elapsed time between operations are reversed as compared to rational CEOs. This is a result reported in Conn *et al.* (2004) (at the organizational level).

Finally, notice in Figure 5 – Panel C, that the predicted time path of the absolute value of the CAR has the same general shape for both rational and hubris infected CEOs.

3.4. Other implications

Equation (15) also has implications about the threat of dismissal (μ_L and σ_L^2), the CEO's bonus (*b*), his risk aversion (*γ*) and the impact of diversification ($\sigma_{\tau,s}$). For the sake of brevity, we do not present a full analysis but present some numerical examples. The example parameter values are presented at Table 1 – Panel A. Table 1 – Panel B gives the optimal solution and its associated probabilities. The parameters are chosen such that the expected synergies ($\hat{\mu}_{s,t}$) are equal to the actual value of the target's current operating profit (μ_τ) but are riskier. They are positively correlated ($\rho_{\tau,s}$ is equal to 0.3). The

CEO's expected loss conditional on dismissal (μ_L) is significant (10% of the expected bonus) and uncertain (coefficient of variation of 2). The risk aversion coefficient (γ) is 3, and the maximum premium that could be offered for a target (θ) is 2. The simulation results are presented in Figure 6 and 7. Charts on the left present the optimal premium rate while charts on the right present the evolution of the probability regions (No Deal, Deal and CEO Retention, and Deal and CEO Dismissal).

Firing Sanctions

Figure 6 presents the impact of loss upon dismissal (μ_L) and its variance (σ_L^2), in Panel A and Panel B respectively. As expected, their impact on the optimal premium rate is negative. Both higher and more uncertain losses make the risk averse CEO more cautious.

Variable Compensation Coefficient

Figure 7 – Panel A depicts the positive impact of variable compensation (*b*) on the optimal premium rate. Here again, the results are in-line with intuition. In order to induce more aggressive bidding, bonuses specific to deal completion must be available, as is observed in practice (see Grinstein and Hribar, 2004).

CEO Risk Aversion

The proposed optimal premium decreases with the degree of CEO risk aversion (see Figure 7 – Panel B). This could be tested by using proxies of personal risk aversion (such as personal wealth, used in Becker (forthcoming *Journal of Finance*)).

Current Target Activities and Synergies Correlation

A high correlation between the target's current activities and expected synergies increases the variance of the expected bonus, ceteris paribus, and reduces the optimal premium (see

Figure 7 – Panel C). This result provides a rational foundation to the diversification effect observed in the M&A literature (see, among others, Fan and Goyal, forthcoming *Journal of Business*). But our explanation is not based on lower expected synergies in the case of unrelated acquisition; it is instead a mechanical consequence of the rational decision made by a risk-averse and under-diversified CEO who is attempting to limit his personal risk exposure. A lower covariance between the target's current activities profits and expected synergies (the more they are unrelated) implies a lower variance of the CEO's future compensation in case of deal completion. This in turn leads to a higher bid price, and lower abnormal returns for bidders around the announcement date. Hence, the observed difference between related and unrelated acquisitions might have nothing to do with lower expected synergies but could simply be the consequence of the CEO's rational behavior during the bidding process.

4. Conclusion

M&A operations offer an interesting (almost) experimental framework to analyze CEO decision making. M&A decisions involve a large commitment of human, financial and organizational resources. Moreover, the CEO's future career often depends on their success.

Several recent empirical contributions (Fuller et al. (2002), Bradley et al. (2004), Conn et al. (2004) among others) indicate that, in a sequence of M&A deals involving the same firm, the bidding firm's abnormal return declines from deal to deal. This has been interpreted as an indication that CEOs do not learn from past experience. But why should CEOs be unable to learn from previous M&A decisions?

To explore this issue, we first develop a rational expectations model of CEO M&A decision making. We then introduce learning and hubris, the latter as either over-optimism or over-confidence. Our model delivers interesting insights and new testable implications. Most important, we find that a declining pattern of bidding firm returns from deal to deal is actually compatible with learning. In fact, it is what we should expect to find when CEOs are rational and risk averse, and are learning.

Our analysis suggests particular caution when interpreting empirical results in the M&A field. Two endogenous sample selection biases are competing. The first is due to the winner's curse bias specific to the auction nature of the M&A bidding process. The second is CEO survival bias due to intervention of corporate governance sanctions following bad deals. Which bias dominates is an empirical issue that will have to be resolved by future research.

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Table 1. Parameters for Numerical Results

Table 1 displays the set of parameters (Panel A) used to compute the numerical examples presented in Section 3 and the optimal premium π^* and probabilities ϕ_i^* (Panel B).

Coefficient	Description	Value
Panel A – Model Parameters		
$\hat{\mu}_s$	Expected synergy	25
$\hat{\sigma}_s$	Standard deviation of expected synergy	2.5
μ_τ	Expected profit of target's current activities	25
σ_τ	Standard deviation of expected profit of target's current activities	1.25
b	Variable part of the compensation contract	0.001
μ_L	Expected firing sanctions	0.05
σ_L	Standard deviation of expected sanctions	0.1
$\rho_{s,\pi}$	Synergies/Profit correlation	0.3
θ	Maximum premium	2
γ	CEO's risk aversion coefficient	3
Panel B – Optimal Premium *PM*		
$\pi^*/(\theta-1)$	Optimal Premium rate	0.20
$1-\varphi_S^*$	Optimal Probability of No Deal	0.79
$\varphi_S^*(1-\varphi_F^*)$	Optimal Probability of Deal and CEO Retention	0.16
$\varphi_S^*\varphi_F^*$	Optimal Probability of Deal and CEO Dismissal	0.04

	Unconditional probabilities	CEO compensation

No Deal $\qquad (1-\varphi_S)$ $\qquad W$

$(1-\varphi_S)$

$(1-\varphi_F)$

Deal and CEO Retention $\qquad \varphi_S(1-\phi_F)$ $\qquad W-L$

φ_S

φ_F

$W+B$

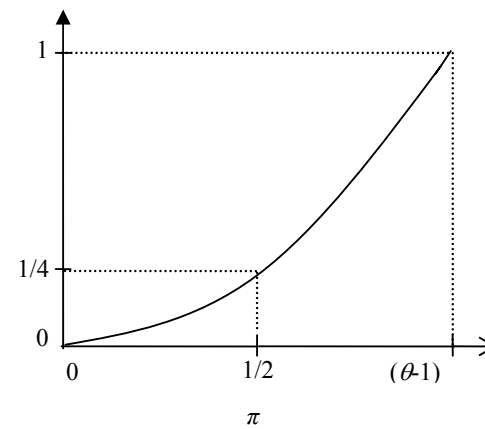Deal and CEO Dismissal $\qquad \varphi_S\,\varphi_F$
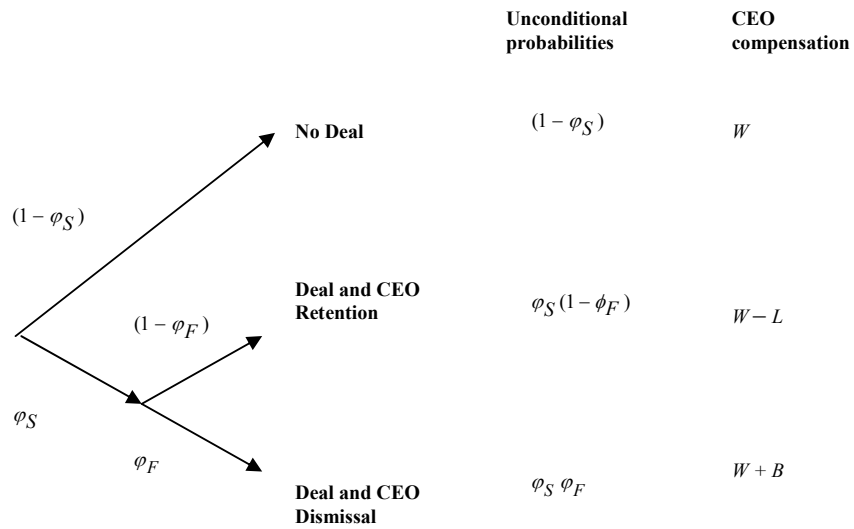
Fig. 1. The CEO's decision problem. φ_S denotes the probability of a successful deal and φ_F the probability of being dismissed after shareholder value destruction, conditionally on having done the deal. W, B, and L denote, respectively, to the present value of the CEO current compensation, the bonus in after deal completion and the dismissal loss.
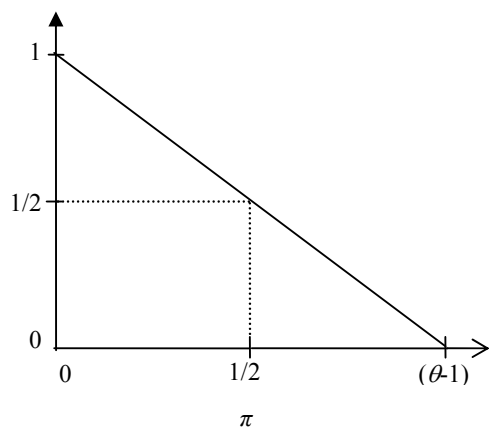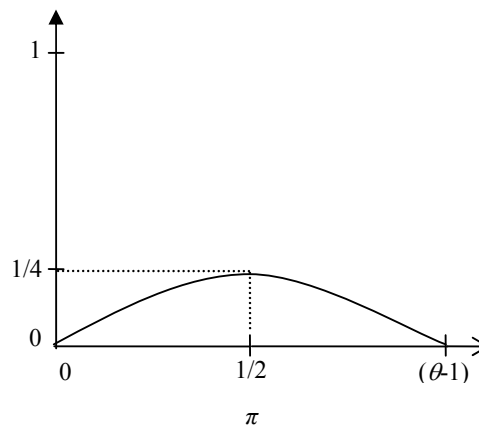
Panel A. No Deal   Panel B. Deal and CEO Retention   Panel C. Deal and CEO Dismissal

Fig. 2. The unconditional probabilities as a function of the bid premium π. Panel A plots the probability of missing out on the deal, which decreases linearly as π increases. Panel B shows the probability doing the deal and not being fired. Panel C plots the probability of being fired, knowing that the CEO has won the bidding game. The y-axis gives the probability, and the x-axis gives the level of π.
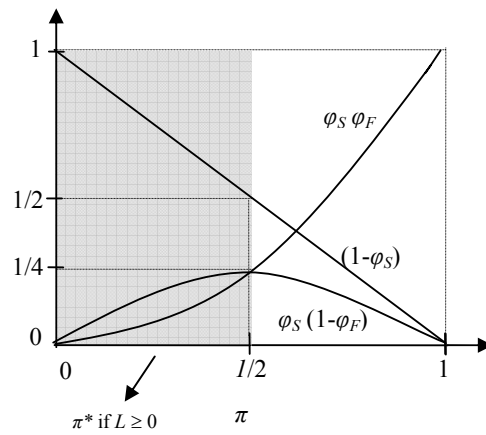
Fig. 3. Optimal solution and parameter space constraints. This figure plots the unconditional probabilities as functions of the bid premium π. The y-axis gives the probability, and the x-axis gives the level of π. $(1-\varphi_S)$, $\varphi_S(1-\varphi_F)$, and $\varphi_S(1-\varphi_F)$ correspond to the probability of "No deal", "Deal and CEO Retention", and "Deal and CEO Dismissal", respectively. The optimal solution (π^*) must be smaller than 1/2 if the firing loss L is positive (see Section 1.4).
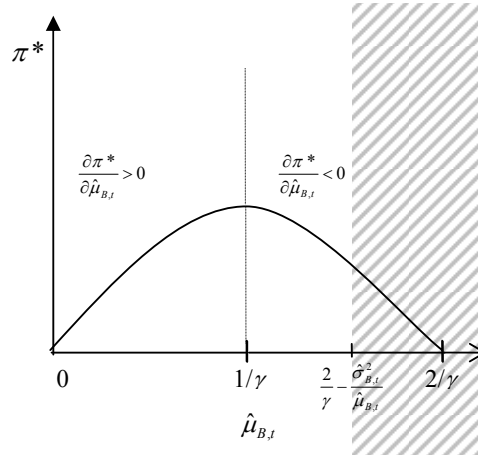
Fig. 4. The optimal premium as a function of the (perceived) expected bonus. This figure plots the optimal bid premium with respect to $\hat{\mu}_{B,t}$, which is the perceived expected bonus in case of deal completion. The dashed area denotes the zone of inadmissible parameter values. Indeed, if $\hat{\mu}_{B,t} > (2/\gamma) - (\hat{\sigma}^2_{B,t}/\hat{\mu}_{B,t})$ than some unconditional probability outcomes are negative.
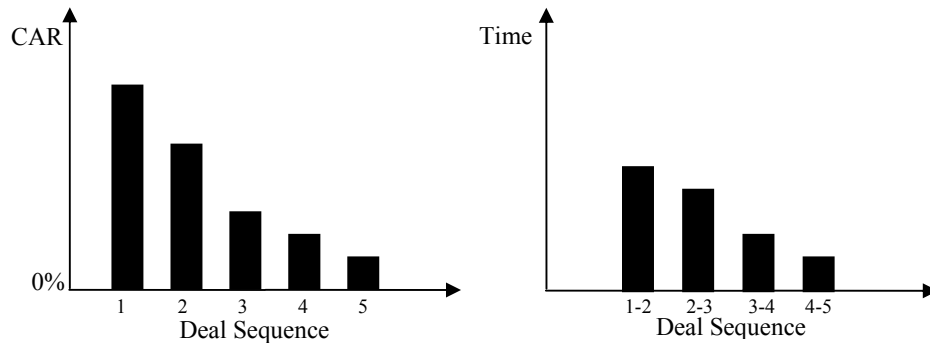
Panel A. Rational CEOs
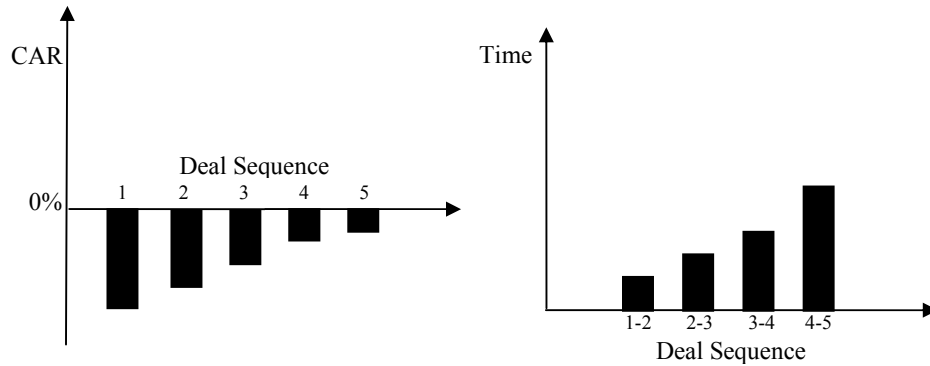
Panel B. Hubris infected CEOs
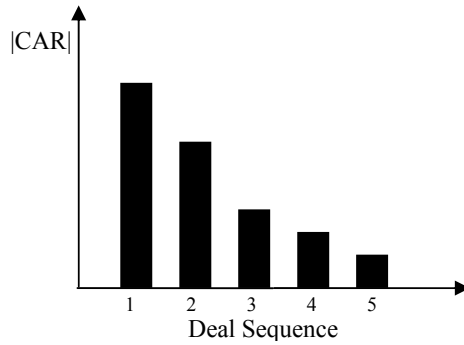
Panel A. All CEOs

Fig. 5. Bidder cumulative abnormal returns (CAR) and time between successive deals. The X-axis represents the deal sequence order number in an acquisition program undertaken by the same CEO. The Y-axis is either the ex-post observable CAR or the time duration between two successive deals. Panel A – left chart, considering rational CEOs, shows the declining pattern of ex-post observable CARs from deal to deal, as a consequence of the learning process. The associated right chart highlights the shortening delay between successive deals. Panel B, focusing on hubris infected CEOs, illustrates the opposite conclusion. Panel C shows that the absolute values of successive CARs exhibit the same general pattern for rational and hubris infected CEOs under an assumption that both are learning.
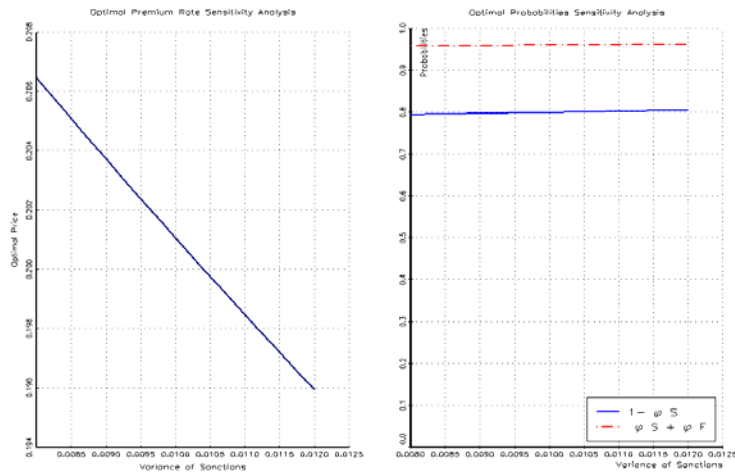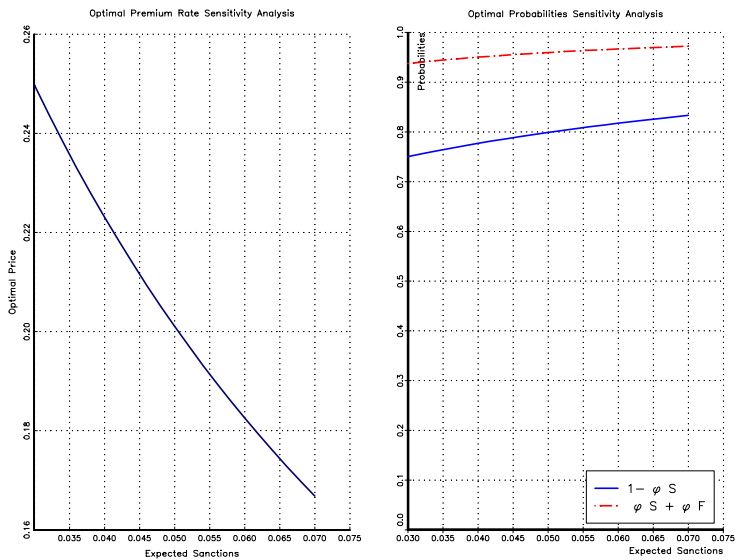
Panel A – Expected Firing Sanctions

Panel B – Variance of Expected Firing Sanctions

Fig. 6. This figure shows the impact of expected firing sanctions (Panel A) and their variance (Panel B) on the optimal premium (π^*). The left graphs plot the optimal premium, while right graphs show the optimal probabilities. The parameter values are provided in Table 1 – Panel A.
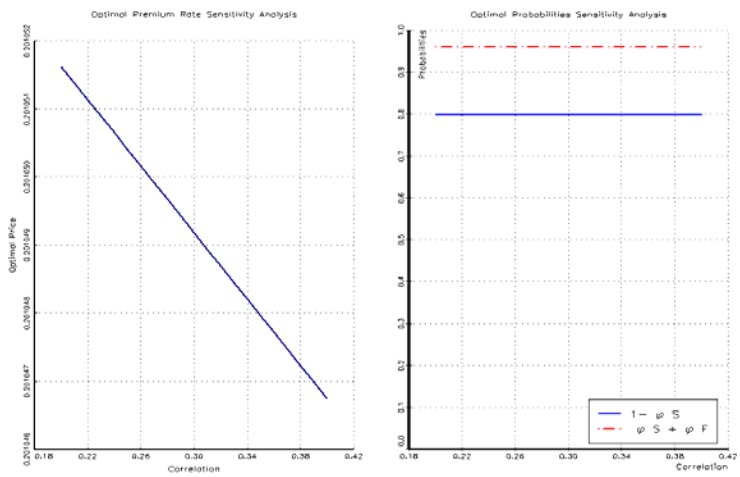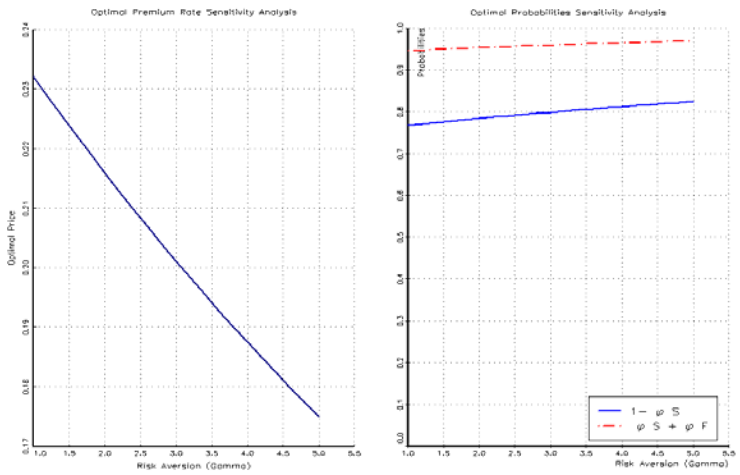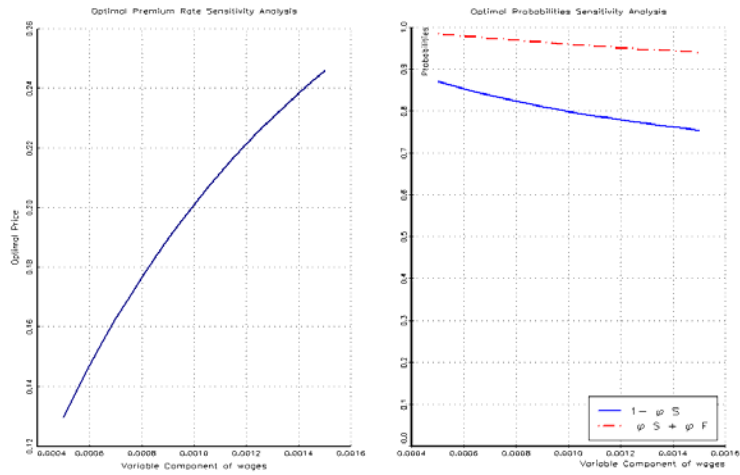
Panel A – Variable Compensation Coefficient

Panel B – CEO Risk Aversion

Panel C – Correlation between Current Target Activities and Synergies

Fig. 7. This figure shows the impact of the variable compensation coefficient (*b*) (Panel A), CEO risk aversion (Panel B) and the correlation between current target activities and synergies (Panel C) on the optimal premium (π^*). The left graphs plot the optimal premium, while right graphs show the optimal probabilities. The parameter values are provided in Table 1 – Panel A.