Qual Quant (2015) 49:2459–2480
DOI 10.1007/s11135-014-0122-8

# Organizational decision-maker bias supports merger wave formation: demonstration with logical formalization

**Gábor Péli · Hans Schenk**

Published online: 12 November 2014
© Springer Science+Business Media Dordrecht 2014

**Abstract** Imitation of firms that opt for strategic reorganizations by opting for mergers and acquisitions facilitates market wave formation. Empirical evidence on mergers and acquisitions suggests that, under uncertainty, firms regret more not following their rivals' merger moves of yet unknown outcome than possibly failing jointly by copying them. Looking for the rationale for this bandwagon behavior, we explore the underlying decision-making framework by using formal logic and search for behavioral premises consistent with the observed outcomes. We point out three biased expectations, modeled by using a *belief* modal operator, that filter out relevant scenarios from the consideration set of otherwise rationally behaving decision-makers. The theorems derived from the logic model highlight the drive to imitate competitors' merger choices for all but one of the eight possible outcomes of the decision-making framework. For the latter case, a boundary condition is given that makes imitation the predicted strategy. Our approach goes against the view that human behavior defies logic-based rendering also if such behavior can be adequately described as non-rational in an economic sense. Logic is a flexible representation tool to model even faulty behavior patterns in a transparent way; it can also help exploring the consequences of the cognitive mistakes made. Our findings suggest that threats to wealth creation may not necessarily find their origins in morally questionable organizational behavior, but rather in modalities of decision-making under uncertainty.

**Keywords** Logical model · Deductive reasoning · Perception bias · Merger waves · Regret minimizing

G. Péli (✉) · H. Schenk
School of Economics, Utrecht University, Utrecht, The Netherlands
e-mail: g.peli@uu.nl

H. Schenk
Social and Economic Council of The Netherlands, The Hague, The Netherlands

## 1 Introduction

The research reported in this paper studies the behavioral background of merger wave formation by using a non-mainstream tool of demonstration, i.e. model building with symbolic logic (Gamut 1991a, b). It intends to contribute to the research line that investigates how the behavior of influential individuals in organizations aggregates into robust macro-level market outcomes. These macro-level outcomes may be influenced by strategic decisions depending on factors like the personality traits and functional backgrounds of top management team members (Hambrick 2007; Hiller and Hambrick 2005), as well as on their internal versus external locus of control (Boone and Hendriks 2009). Past success in a given market context can boost diversification drives in an otherwise unjustified manner (Barnett and Pontikes 2008). Norm-making processes can spread and solidify faulty decision-making patterns by setting the individual compasses of managers to point in the same direction, delimiting what they are likely to do or even perceive (DiMaggio and Powell 1983). Our paper does not address the delicate institutional and cognitive mechanisms via which prevalent managerial norms and decision-making patterns develop. Instead we explore by means of logical modeling the consequences of biased managerial perception on managerial decision-making, which latter may facilitate merger and acquisition wave formation.[1] Mergers and acquisitions (M&As) come in large waves of which six have been documented in modern history, between 1895 and 2008 (Town 1992; Gugler et al. 2005). Figure 1 shows the considerable deviations from the long run mean.

Empirical studies have repeatedly shown that most large M&As fail to generate wealth relative to the counterfactual, both in terms of virtual wealth (i.e. stock market value) and real wealth (i.e. profit, productivity, market share growth, or innovation output) (Schenk 2006; Scherer 2006). These findings—which apply to recent as well as past M&A waves—make M&A wave formation a particularly interesting phenomenon to study. Following such waves we typically observe deteriorating economic fortunes (recessions) and heightened demerger and sell-off activity. This recurrent pattern suggests that merger and acquisition-active firms must be aware of the questionable chances for success. Still, this does not appear to hold them back. Why would firms recurrently and periodically undertake so many M&As even though it is known that the chances for wealth creation are small? The dynamics of M&A patterns suggest that many firms undertake non-wealth creating acquisitions precisely when other firms are doing the same. We suggest that these patterns in some way are the result of a contagious or imitative process. Earlier models of social diffusion and contagion aim at explaining how imitation coheres into cascade propagation in networks of interacting agents (Granovetter 1978; Watts 2002). We investigate the step that *precedes* imitation, identifying motives that make agents imitate. Our formal model is based on, and extends, an earlier *minimax-regret argument* of Schenk (1996). This argument captures the managerial behavior underlying seemingly irrational M&A decisions by putting a floor under how bad a decision-maker would feel if things go wrong.[2] It applies in small-number rivalry conditions, i.e., when a gain for firm $A$ will have significant repercussions for firm $B$. Such conditions, while recognized as special cases in textbook economics, are typical for several relevant sectors of developed economies. Fewer than ten firms dominate world car markets, drugs markets, oil

[1] Since the literature normally does not make a distinction between merger and acquisition (or takeover), neither will we in this paper. In fact, however, mergers are rather rare, approximately only ten per cent of the total number of transactions (Schenk 2006).

[2] The minimax regret approach is to minimize the worst-case regret and was initially developed by Savage (1951).

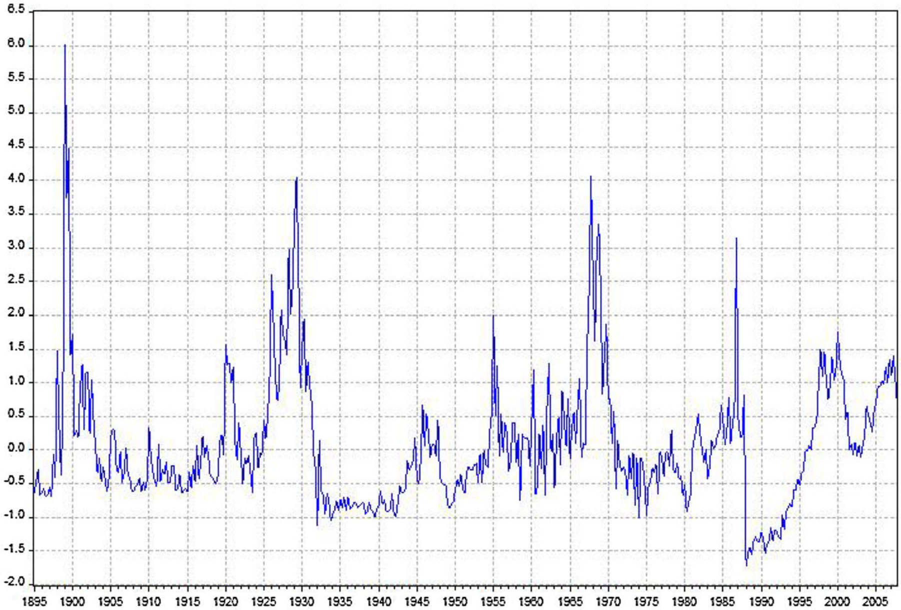


**Fig. 1** Spliced and normalized frequencies of merger/acquisition series for the United States. Data for 1895–1987 comes from Town (1992), while data for 1988–2007 is based on the Thomson ONE Banker database; see http://banker.thomsonib.com

markets and telecom markets (Pryor 2001). Similar conditions apply in the banking industry (Bikker and Haaf 2002).

Schenk's argument (1996) can be summarized as follows. Suppose that firm $A$ announces the acquisition of some firm $C$. Competitor firm $B$ will now have to contemplate what the repercussions for its own position might be. $A$'s competitive position vis-à-vis its peers may be ameliorated as a result of that move, say, in terms of a first-mover advantage.[3] But then again, it may not. What is $B$, the focal firm in our investigation, to do? Suppose that $A$'s move succeeds but that $B$ has not reacted by imitating that move itself (scenario $\alpha$). Alternatively, suppose that $A$'s move fails but that $B$ has imitated it solely inspired by the possible prospect of $A$'s move being a success (scenario $\beta$). $B$'s regret attached to scenario $\alpha$ is expected to be higher than its regret attached to $\beta$. For in $\alpha$, $B$ will experience a loss of competitiveness, while in $\beta$ its competitive position vis-à-vis $A$ will, ceteris paribus, not have been harmed. Of course, $B$ could have realized a gain by not wasting time and assets on the acquisition, had it refrained from imitating $A$. But in markets of intense face-to-face competition, $B$'s concern is improving, or at least maintaining, its strategic position relative to competitors. So not opting for M&A brings about the fear of missing an opportunity that competitors will utilize. Therefore, $B$'s regret of forgoing the potential M&A gain is likely to be small relative to the regret concerning the expected robust disadvantage in its competitive position if $A$ succeeds. The qualitative implication is that a strategic move by firm $A$ is likely to elicit an imitative countermove by its rival $B$, even if the economic advantages are questionable.

[3] The literature normally calls first movers those firms that enter a new market segment first (Lieberman and Montgomery 1988; Péli and Masuch 1997). We use this concept in a broader sense: first movers are those that first utilize a new market opportunity (e.g. a hypothetical M&A advantage), or even more general, those that move first in a sequential game setting.

The most frequently used way for modeling regret-minimizing strategies under face-to-face interactions is applying game theory and specifying equilibrium conditions (Hart and Mas-Colell 2003; Schlag and Zapechelnyuk 2010). Our approach, however, investigates an earlier phase in which certain agents decide to enter the game or not. In our model, first-mover firm $A$ has already started its merger or acquisition, and now it is prospective follower $B$'s turn to react. Why does firm $B$ regard following $A$'s move to be the better option, as observation suggests and the qualitative minimax-regret argument indicates? Which motivations lead to imitative tendencies, and so in aggregation, to M&A waves? We consider that decision-makers may be systematically biased in some of their beliefs concerning competitive dynamics and adaptation (which does not rule out unbiased behavior in other circumstances). So we expect managers to behave 'logically', except for a few aspects that might turn out to be crucial.

We use symbolic logic as modeling tool (Gamut 1991a, b) and translate the regret-minimizing argument into logical formulae. First providing a natural language reconstruction of the decision-making problem, we subsequently seek for behavioral assumptions, beliefs that managers share. Then, we formalize these beliefs as model premises in order to derive the qualitative minimax-regret conclusion that follower firm $B$attaches higher regret to idleness (scenario $\beta$) than to joining the merger bandwagon and risking failure (scenario $\alpha$). Building-up a logic machinery to solve a single problem might seem like shooting a sparrow with cannon. But we make further use of the model by extending the theory and deriving yet unexplored consequences. We demonstrate that the premise set extended with bits of new information gets strong enough to survey the complete set of strategic outcomes that can occur in prospective follower $B$'s decision-making framework. Moreover, we derive some generalized theorems that also indicate that managers tend to overlook those scenarios that suggest not joining the bandwagon. Logical formalization is a qualitative formal method that allows drawing conclusions from natural language arguments with the rigor of mathematical derivations (Bruggeman and Vermeulen 2002). After translating the focal concepts (definitions, meaning postulates), facts and considerations (assumptions) of the theory under investigation into formal logical sentences, the goal is to get the theory's conclusions as theorems. Logic appears a flexible and accurate formal tool even for investigating erratic human behavior. Theorizing about illogical human behavior can be, and should be, put forward logically.

Different logical languages can be chosen like mainstream first-order logic (FOL, Péli and Masuch 1997; Kamps and Pólos 1999; Péli 2009), or possible extensions such as non-monotonic logic (Veltman 1996; Pólos and Hannan 2004; Kuilman et al. 2009) and modal logic (Gamut 1991b). Non-monotonic logic is a powerful tool to build theories 'in the move' thanks to its ability of tolerating exceptions from the rules distilled from empirical generalizations (Lakatos 1976). We specified our current behavioral model without such knowledge update. To keep the presentation simple, we therefore built our modal logic construction upon FOL. Modal logics increase FOL's expressive power by introducing operators that attach modalities to statements. Examples for modalities are being *'necessary'*, *'possible'*, *'known'*, and *'believed'*. We make a distinction between two epistemic layers: what agents know (correctly, *per definitionem*) and what they believe (correctly or not). Beliefs act as perception-filters preventing decision-makers from considering the full set of outcomes of their choices. We employ two modal operators, the **B** *belief* operator with its standard axiomatization and the **K** *knowledge* operator (Herzig and Longin 2003). **B** $\varphi$ denotes that the belief prevails among the managers of firm $B$ that $\varphi$ holds, while **K** $\varphi$ denotes that they know that $\varphi$ holds. We put the formal characterization of **B** and **K** into Table 6 in the Appendix. Note, however, that being able to read and to appraise our formalization does not require specific logic skills, just like studying a simulation paper does not require being a programmer. We provide the logic essentials in the course of the formalization process.

## 2 Logical formalization

We proceed with the formalization by first motivating our definitions and assumptions in natural language and then spelling them out in logic. Then, we derive theorems from our premise set. A conclusion can be challenged in two ways: either by showing that its derivation is incorrect or by showing that some of its premises are. We checked the FOL core of the derivations with the *Prover9* and *Mace4* theorem-prover softwares freely available on the Internet (McCune 2011). So our conclusions are as good as the premises from which they derive. Logical formalization has the convenient property that its arguments can effectively be challenged by pointing out that some premises cannot be taken for good. Replacement of those premises again allows the formal exploration of conclusions. Logical formalizations, just like formalizations in mathematics, build on a bulk of background knowledge. We took as given, without formalization, that firms $A$ and $B$ are in rivalry in a high uncertainty market. Their managers of bounded rationality (Simon 1955) resort to beliefs to patch up information gaps. We also took for granted that firm $A$ has already opted for a merger or acquisition that could be imitated by firm $B$. The advantageous market position after a successful merger is captured by the organizational fitness it brings about or maintains. Since even successful mergers involve substantial reorganization costs, the general well-being of our firms depends on the difference between their fitness and reorganization cost scores.

In order to keep the focus on the interplay between logical formulae and organizational content, we have only put upfront in the main text the definitions and assumptions that are closely related to the theory. Some premises, for example those on elementary arithmetic, have been put in the Appendix (Tables 4, 5). Table 1 displays the denotations of the logical language, as well as the vocabulary of proper names, predicates and function symbols. To make the formulae shorter, we apply the convention that the 'for all' (∀) quantifier at the outmost left position is omitted. To get familiar with the logic machinery, we give 'reads' after formulae that instantiate the notations and vocabulary items from Table 1 into the formulae. Next, we are going to derive the prediction of the minimax-regret argument that firm $B$ prefers scenario $\beta$ over $\alpha$. In formal terms: $Prefers(B, \beta, \alpha)$. Following their natural language descriptions in part 1, scenarios $\alpha$ and $\beta$ are defined as follows.

**Definition 1** Scenario $\alpha$.

$$Holds(\alpha) \leftrightarrow Opts\,(A) \wedge Fit\,(A) \wedge \neg Imitates\,(B, A)$$

(Scenario $\alpha$ holds, if and only if $A$ opts for M&A and $A$ is fit and $B$ does not imitate $A$.)

**Definition 2** Scenario $\beta$.

$$Holds(\beta) \leftrightarrow Opts(A) \wedge \neg Fit(A) \wedge Imitates(B, A)$$

(Scenario $\beta$ holds, if and only if $A$ opts for M&A and $A$ is not fit and $B$ imitates $A$.)

Fitness comes from the correspondence between firm posture and the task environment (Thompson 1967). A firm is fit if its structural settings enable it to operate effectively and efficiently under the given market conditions. Definition 3 fixes that preferring an outcome to another is identical to expecting to be better off with the former. We use the terms '$B$ prefers' and '$B$ believes' as abbreviations for the facts that the decision makers of firm $B$ do so, respectively.

**Table 1** Denotations of the logical language

| | |
|---|---|
| Logical connectives, in order of their decreasing binding strength | |
| $\neg$ (negation), $\wedge$ ('and'), $\vee$ (inclusive 'or'), $\rightarrow$ (implication, 'if ... then'), $\leftrightarrow$ (bi-implication, 'if and only if') | |
| Quantors | |
| $\forall$ | Universal quantification ('For all') |
| $\exists$ | Existential quantification ('There exists') |
| Modal operators over sentence $\psi$ | |
| $\mathbf{B}\psi$ | Firm $B$ believes that $\psi$ holds |
| $\mathbf{K}\psi$ | Firm $B$ knows that $\psi$ holds |
| Proper names | |
| $A$ | First-mover firm $A$ |
| $B$ | Potential follower firm $B$ |
| $fi$ | The advantage that fitness brings about |
| $rc$ | The reorganization process costs of the M&A |
| $\alpha, \beta$ | Scenarios $\alpha$ and $\beta$ |
| $s_i, s_{i,j}$ | Basic scenario $i$, composite scenario of $s_i$ and $s_j$ |
| 0, 2, 4 | - Integers 0, 2, and 4 |
| Predicates | |
| $Better\_off(z, x, y)$ | $z$ is better off with $x$ than with $y$ |
| $Composite(x, y, z)$ | $x$ is the composite scenario of $y$ and $z$ |
| $Firm(x)$ | $x$ is a firm |
| $Fit(x)$ | $x$ is fit |
| $Imitates(x, y)$ | $x$ imitates $y$ |
| $Indiff(z, x, y)$ | $z$ is indifferent w.r.t. the choice between $x$ and $y$ |
| $Holds(x)$ | $x$ holds |
| $Opts(x)$ | $x$ opts for M&A |
| $Prefers(z, x, y)$ | $z$ prefers $x$ to $y$ |
| $ReorgCost(x)$ | $x$ has reorganization process cost |
| $Scen(x)$ | $x$ is a scenario |
| $x = y$ | $x$ is equal to $y$ |
| $x > y$ | $x$ is larger than $y$ |
| Functions | |
| $f(x)$ | The fitness of $x$ |
| $min(x)$ | Minus $x$ |
| $r(x)$ | The reorganization costs of $x$ |
| $rel.payoff(x)$ | The payoff of $x$ relative to the payoff of $A$ |
| $payoff(x)$ | The payoff of $x$ |
| $p(x)$ | The probability of $x$ |
| +, −, *, / | Arithmetic operations |

We adopt the convention of omitting universal quantification from the beginning of formulae. Existential quantification ($\exists$) does not occur in the current model version

**Definition 3** Firm $B$'s preference.

$$Prefers(B, x, y) \leftrightarrow \mathbf{B}\{Better\_off(B, x, y)\}$$

($B$ prefers $x$ over $y$, if and only if, $B$ believes to be better off with $x$ than with $y$.)

We use the **B** operator to represent some managerial beliefs that influence their strategic decisions. Note that to get our theorems, we do not, and need not, assume that managers of all M&A-prospector firms in the given market share these beliefs. But beliefs may earn norm-like status, delimiting the legitimate set of actions to the extent that even non-believers feel normative pressures to act as the beliefs imply or suggest (DiMaggio and Powell 1983). Note also that there is no need to specify the 'strength' of the beliefs numerically in the formal model we are going to build. It is enough to assume that these beliefs are strong enough to make our decision-makers act according to them.

Assumptions 1–3 on beliefs act as heuristics, rule-of-thumbs for managers, influencing strategic decisions, and thus aggregate market outcomes. What these assumptions state are well-known in the business world; they also recur in mainstream management textbooks. The first belief is that organizational adaptation is a must in competitive markets: idleness under rapidly changing external conditions bears failure (Assumption 1). Managers are hired to take action. Those who stay idle in turbulent times can be perceived way more negatively than those who fail but 'at least tried to do something', even when rationality would not have justified their actions. In the current context, embarking upon a merger or acquisition is the adaptive move organizations can make.

**Assumption 1**

$$\mathbf{B}\{Firm\,(x) \wedge \neg Opts\,(x) \rightarrow \neg Fit\,(x)\}$$

($B$ believes that if $x$ is a firm and $x$ does not opt for M&A, then $x$ is not fit.)

Assumption 1 corresponds to a belief that opting for adaptation, which is opting for M&A in the current context, is a necessary condition for achieving/maintaining fitness. As being fit means having achieved a good correspondence between firm posture and the firm's task environment, *ceteris paribus*, fitness improves the strategic position relative to competitors. But the *ceteris paribus* condition is, in general, not guaranteed to hold. Therefore Assumption 1, alone, does not guarantee that rationally behaving firms will opt for M&A. A structurally fit firm can well be in trouble if the adaptation costs associated with the acquisition exceed the benefits a successfully implemented acquisition can bring about (cf. Assumption 3 below). Moreover, even when adaptation costs undercut fitness benefits, competitors may have the same fitness at possibly lower adaptation costs. The formalization below translates these considerations into model constructs in a stepwise manner.

The second model assumption is about what management textbooks call benchmarking: the imitation of good practices, if done properly, is expected to lead to similar good results (here, to fitness). The analogue statement is that imitation of bad practice breeds failure.

**Assumption 2**

$$\begin{aligned}&\mathbf{B}\{Firm(x) \wedge Firm(y) \wedge Imitates(y, x)\\&\quad \rightarrow (Fit(x) \rightarrow Fit(y)) \wedge (\neg Fit(x) \rightarrow \neg Fit(y))\}\end{aligned}$$

($B$ believes that if $x$ and $y$ are firms, and $y$ imitates $x$, then $x$ is fit implies that $y$ is fit, and that $x$ is not fit implies that $y$ is not fit.)

Assumption 2, just like Assumption 1, puts forward what the decision-makers of firm $B$ believe without claiming that their beliefs are justified. One way of questioning the belief expressed by Assumption 2 is arguing that conditions can substantially change during the time lag during which $B$ can potentially follow $A$'s initial move. Ruef (2006) has demonstrated that the 'boom and bust' cycles in organizational funding and disbanding can be fueled by entrepreneurial inertia, the latter being conceptualized as a lag in response between the initiation of new organizations and the startup of these organizations. The logical formalization study of Kuilman et al. (2009) operates with a similar conjecture: elongated pre-entry organizer periods, *ceteris paribus*, can reduce proto-organizations' alignment to external conditions; as a consequence, elongated pre-entry periods can even decrease survival perspectives beyond a certain pre-entry period length. Even if the lag between initiation and startup is modest, so that market conditions do not change drastically for external reasons in the meantime, endogenous change can occur even in the shorter run. By reaping the first-mover advantages, $A$ may be deteriorating the conditions for subsequent M&As, e.g. by picking the best targets or by making the residual targets aware of the danger of unwanted acquisitions. In another logical formalization study, Péli and Masuch (1997) have demonstrated that in case of rapid endogenous environmental change, an efficient producer strategy (entering after a longer gestation period but with well-developed structure) can be inferior to a first-mover strategy (entering a new market fast but with roughly-built structure).

M&As normally involve fundamental reorganizations that affect the organization's technical core (Thompson 1967). Fundamental reorganizations reshuffle basic routines (Nelson and Winter 1982) and disrupt tacit agreements upon which personal and systemic trust is based (Lane and Bachmann 1998). Reorganizations can involve costs on two accounts (Barnett and Carroll 1995). If a firm fails to achieve the reorganization goals, or achieves wrongly chosen goals so that the adaptation effort does not bring about or maintain fitness, then the firm faces the *content* costs of reorganization. We take into account the content costs of failed M&As by omitting the $fi > 0$ fitness advantage that would be included in case of successful adaptation to market conditions (A.10.5, in Appendix Table 5). While content costs are only paid in case of adaptation failure, firms always pay the $rc > 0$ *process* costs of the reorganization. Our focal firm $B$ lacks insider information on the ongoing merger of its rival $A$. Therefore we assume that $B$ expects, by default, the same $rc$ reorganization costs for itself as for $A$. Similarly, $B$ expects having the same $fi$ fitness bonus after successful mergers. Having respectively different $fi$-s and $rc$-s for $A$ and $B$ gets importance at the phasing out of the wave ('Ending the wave' in Appendix). We emphasize that the model does not, and need not, assume that $B$'s expectations concerning $fi$ and $rc$ are accurate. What we prove below is that $B$'s beliefs would distort its judgment and so facilitate making suboptimal decisions even in case $B$'s expectations on these values were accurate. Expecting high $fi$ reflects hopes on strategic positioning advantage and efficiency improvement. Empirical data reveal that such expectations fall far from being justified: the overwhelming majority of M&As fails to improve productive efficiency (Schenk 2006; Scherer 2006). Still, there are systematic managerial tendencies to underestimate the costs relative to the fitness improvement a successful adaptation might bring about (Hannan and Freeman 1984). Assumption 3 formalizes this belief for firm $B$.

**Assumption 3** $\mathbf{B}\{fi > rc\}$

($B$ believes that the $fi$ fitness advantage that a successful M&A brings about is larger than the $rc$ reorganization process costs.)

Our model also assumes that $B$'s beliefs are not systematically biased in any relevant sense beyond the assumptions that express beliefs (Assumptions 1–3 and later: A3*). So with these exceptions, $B$ also knows the facts on the context captured by the premise set. In general, firm $B$ behaves rationally, as far as its perception bias allows for rational behavior. We assume that $B$ is also well-informed in the sense that it knows the scenario definitions, the organizational context as it is captured by forthcoming Assumptions 4–7, and also the rules of elementary arithmetic (Appendix Tables 4, 5).[4] The next assumption puts forward that opting for M&A involves reorganization process costs.

**Assumption 4**

$$Firm(x) \rightarrow (Opts(x) \leftrightarrow ReorgCost(x))$$

(If $x$ is a firm, then if $x$ opts for M&A, then $x$ has reorganization process costs, and vice versa.)

The bi-conditional ($\leftrightarrow$) in Assumption 4 is shorthand for the fact that the implication also holds in the opposite direction ($\leftarrow$). The 'if and only if' construction indicates a practical model simplification: opting for merger/acquisition is the only source of reorganization cost in our model. Thus from now on we do not consider contexts in which reorganization is triggered by something else like diversification, obsolescence, or factor price change. The next assumption states that once firm $A$ has opted for M&A, firm $B$'s analogue choice qualifies as imitation:

**Assumption 5**

$$Opts\,(A) \rightarrow (Opts\,(B) \leftrightarrow Imitates\,(B, A)).$$

(If $A$ opts for merger, then: if $B$ opts for M&A, then $B$ imitates $A$, and vice versa.)

Assumption 5 also constrains the model, but in a reasonable manner. Its left-to-right reading ($\rightarrow$) fixes that once $A$ has opted for M&A, $B$'s similar move does not happen independently; it is an act of imitation in the given context of face-to-face competition. The right-to-left reading ($\leftarrow$) fixes that the $B$'s imitation takes the form of embarking upon an M&A. With stating that $Firm(A) \wedge Firm(B)$ also hold (A10.1 in Appendix Table 5), the premises listed up till now support two intermediate conclusions. Lemmata 1–2 constitute a springboard for the theorems to come.

**Lemma 1**

$$\mathbf{B}\{Holds(\alpha) \rightarrow Fit(A) \wedge \neg Fit(B) \wedge ReorgCost(A) \wedge \neg ReorgCost(B)\}$$

*(B believes that if scenario α holds, then A is fit, B is not fit, A has reorganization costs, and B has no reorganization costs.)*

**Lemma 2**

$$\mathbf{B}\{Holds\,(\beta) \rightarrow \neg Fit\,(A) \wedge \neg Fit\,(B) \wedge ReorgCost\,(A) \wedge ReorgCost\,(B)\}$$

The bounded rationality of firm $B$'s decision makers reflects their limited information gathering and processing capabilities; therefore, they also hold believes that a perfectly informed rational agent would reject. But being rational in general, they try to estimate the pros and the cons associated with the prospective M&A. So they assign values $(0, rc, fi)$ to the hypothesized fitness advantages and reorganization costs. The $f(x)$ and

[4] The formal logical representation of this latter assumption would require *second-order logic* (Gamut 1991b). Then, the '*for all*' (∀) quantifier would range over the set of formulae that the model applies, while in a first-order logic (FOL) framework it can only range over variables. However, the additional formal rigor that this more sorvarphisticated logic could bring about, would not match the amount of technical and epistemic work that its introduction would take. We can still stay in a first-order frame by applying the **K** knowledge operator, one by one, to all pertaining premises.

$r(x)$ functions yield, respectively, the fitness and reorganization cost values of agent $x$. The $payoff(x) = f(x) - r(x)$ function calculates the payoff for $x$ by lessening its fitness function value (0 or *fi*) by the potential reorganization costs (0 or $rc$). The relative payoff function $rel.payoff(B) = payoff(B) - payoff(A)$ indicates $B$'s overall competitive position relative to $A$ (A10.4–6 in Appendix Table 5). Our agents' rationality also involves believing what they know: $\mathbf{K}\,\varphi \rightarrow \mathbf{B}\,\varphi$ (A11.5, Appendix, Table 6). So they do not express sentences like "I know, I just can't believe it". Moreover, their rationality involves believing the *consequences* of their beliefs: $\mathbf{B}\,\varphi \wedge (\varphi \rightarrow \psi) \rightarrow \mathbf{B}\,\psi$ (A11.1 in Appendix Table 6). So $B$ also believes the payoffs it calculates.[5] We also assume that $B$ makes calculative decisions based on the comparison of scenario payoffs, whenever the pertinent scenarios are perceived, as is put forward by Assumption 6.

**Assumption 6**

$$\begin{aligned} &Scen(x) \wedge Scen(y) \wedge \\ &\quad (Holds(x) \rightarrow rel.payoff(B) = w_1) \wedge (Holds(y) \rightarrow rel.payoff(B) = w_2) \\ &\quad \rightarrow (w_2 > w_1 \rightarrow Better\_off(B, y, x)) \wedge (w_2 = w_1 \rightarrow Indiff(B, y, x)) \end{aligned}$$

(If $x$ and $y$ are scenarios, and if $x$ holds implies having $w_1$ relative payoff for $B$, and if $y$ holds implies having $w_2$ relative payoff for $B$, then if $w_2$ is larger than $w_1$, then $B$ is better-off with $x$ than with $y$, and if $w_2$ equals $w_1$, then $B$ is indifferent with respect to the choice between $y$ and $x$.)

Assumption 6 reflects the consideration that it is the relative strength of competing firms (captured by their relative payoffs between fitness advantages and M&A-related reorganization costs) that determines strategic advantage. The baroque syntax of Assumption 6 also indicates that even a well-understood linguistic expression like 'being better-off ' can be shorthand for complex cognitive constructions. Note that by stating that higher relative payoff is a sufficient condition for being better off, Assumption 6 restricts model generality, disregarding aspects like reputation, subsidies or positive externalities.

Now we are at the point when the premise set implies the main conclusion of the minimax-regret model as a theorem: follower firm $B$ would regret more not imitating first-mover $A$'s successful M&A move (scenario $\alpha$), than failing their respective mergers jointly (scenario *ß*). That is, $B$ prefers *ß* over $\alpha$:

**Theorem 1** *(from D1–3, A1, A3–6)*[6]

$$Prefers(B, \beta, \alpha).$$

*(B prefers scenario ß to scenario α.)*

Figure 2 displays the graph of deduction for the theorems we are going to derive.

[5] Agents should first discover the consequences before believing them. This consideration brings to the problem of logical omniscience in epistemic logics. A11.1 would mean, for example, that all problems of mathematics would be solved, since mathematicians should be able to derive all theorems of their axioms. Therefore, we apply A11.1 with restraints. For example, we assume that our agents believe the consequences of simple arithmetic operations between *fi* and *rc*.

[6] Definition # and Assumption # are abbreviated as D# and A#, respectively. The complete set of premises, including technical assumptions, listed by theorem, can be found in the Appendix under sub-heading 'The theorems and their premises in Prover9 (FOL) format'.

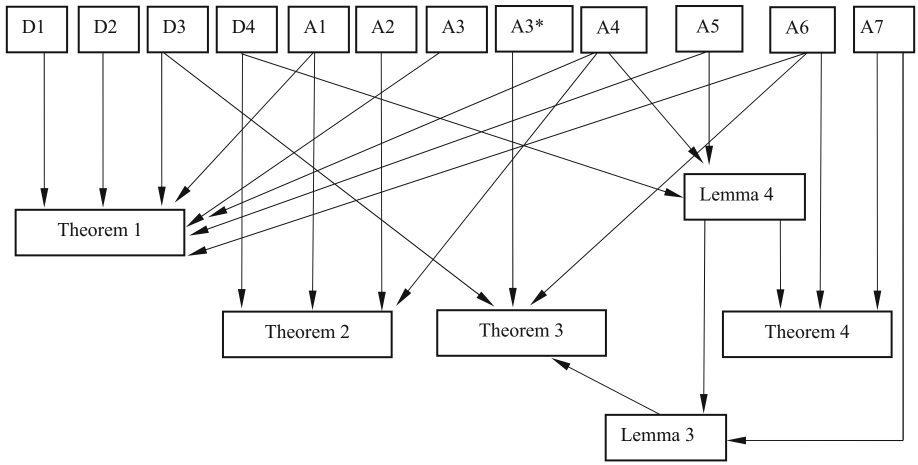


**Fig. 2** The graph of deduction. Displaying all the background assumptions on arithmetic and context would deprive the figure from its transparency; therefore these premises are listed in the Appendix, just as the axioms that characterize the modal operators

## 3 The model at work

Next, we are going to use the logical formalization built up in part 2 for theory extension. We generalize the minimax-regret argument, showing that a slightly extended premise set implies $B$'s preferences over the complete set of scenarios that can occur within $B$'s decision-making framework. $B$'s dilemma is imitating $A$ or not. Both choices can couple with the success/failure of $A$, and also of $B$. These give $2^3 = 8$ basic scenarios (Fig. 3, Table 2). For example, $s_7$ in Table 2 stands for the scenario in which $B$ does not imitate $A$, but still

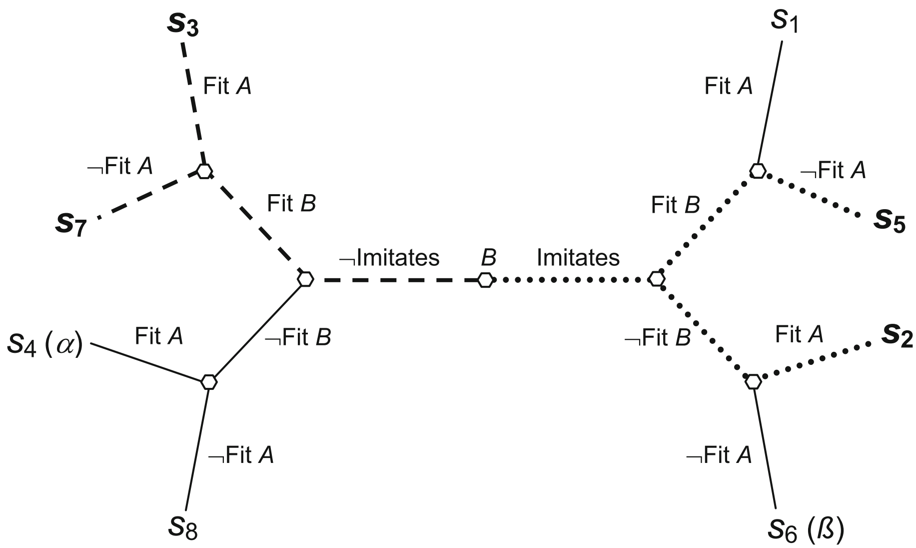


**Fig. 3** $B$'s decision-making tree. Beliefs captured by Assumptions 1 and 2 exclude, respectively, the dashed and dotted branchings, so that $B$ perceives scenario $\alpha = s_{3,4}$ as $s_4$, and perceives $\beta = s_{5,6}$ as $s_6$

**Table 2** Definitions for the eight basic $s_i$ scenarios

Scenarios under which $B$ opts for M&A are in bold

$$\boldsymbol{Holds(s_1) \leftrightarrow Opts(A) \wedge Fit(A) \wedge Imitates(B, A) \wedge Fit(B)}$$
$$\boldsymbol{Holds(s_2) \leftrightarrow Opts(A) \wedge Fit(A) \wedge Imitates(B, A) \wedge \neg Fit(B)}$$
$$Holds(s_3) \leftrightarrow Opts(A) \wedge Fit(A) \wedge \neg Imitates(B, A) \wedge Fit(B)$$
$$Holds(s_4) \leftrightarrow Opts(A) \wedge Fit(A) \wedge \neg Imitates(B, A) \wedge \neg Fit(B)$$
$$\boldsymbol{Holds(s_5) \leftrightarrow Opts(A) \wedge \neg Fit(A) \wedge Imitates(B, A) \wedge Fit(B)}$$
$$\boldsymbol{Holds(s_6) \leftrightarrow Opts(A) \wedge \neg Fit(A) \wedge Imitates(B, A) \wedge \neg Fit(B)}$$
$$Holds(s_7) \leftrightarrow Opts(A) \wedge \neg Fit(A) \wedge \neg Imitates(B, A) \wedge Fit(B)$$
$$Holds(s_8) \leftrightarrow Opts(A) \wedge \neg Fit(A) \wedge \neg Imitates(B, A) \wedge \neg Fit(B)$$

**Table 3** $B$'s relative payoffs under the basic scenarios in decreasing order ($fi > rc$)

| *Scenario* | $s_7$ | $s_5$ | $s_8$ | $s_3$ | $s_6$ | $s_1$ | $s_4$ | $s_2$ |
|---|---|---|---|---|---|---|---|---|
| *B's rel. payoff* | *fi + rc* | *fi* | *rc* | *rc* | 0 | 0 | *rc - fi* | *-fi* |

becomes/remains fit while $A$ does not. The eight scenarios mutually exclude each other. The extant premise set implies $B$'s relative payoffs for each (Table 3).

Let $s_{i,j,k...}$ denote the *composite* scenario that holds exactly when one of basic scenarios $s_i, s_j, s_k, \ldots$ holds. With this denotation in place, Theorem 2 follows in which $B$ believes basic scenarios $s_2$, $s_3$, $s_5$ and $s_7$ not to occur:

**Theorem 2** *(from D4, A1-2, A5)*

$$\mathbf{B}\{\neg Holds(s_{2,3,5,7})\}$$

*($B$ believes that it cannot be the case that any of basic scenarios $s_2, s_3, s_5$ and $s_7$ holds.)*

Comparing Definitions 1–2 with the basic scenario definitions (Table 2) reveals that $\alpha = s_{3,4}$ and $\beta = s_{5,6}$. But because of its perceptual bias, $B$ identifies scenario $\alpha$ with $s_4$ and scenario $\beta$ with $s_6$ (Fig. 3). One of the four overlooked scenarios is well-known to organization scientists. The best-scoring $s_7$ ($A$ fails the M&A while the idle $B$ stays/gets fit, Table 2, 3) is the selection outcome predicted by organizational ecological inertia theory (Hannan and Freeman 1984). The inertia theorem, so much disdained by managers, puts the heretic view forward that under a broad range of conditions, being inert would be a selection advantage. One of its explanations points out that adaptive moves do not affect average population fitness when market change lacks recognizable patterns. Since adaptation involves $rc > 0$ process costs, the advantage would be with those idle firms, if such exist, that match future conditions by chance ($s_3, s_7$, Fig. 3). The anthrax threats after 9/11 have probably boosted the fortunes of gas-mask suppliers even without their making any adaptive market moves (beyond, of course, increasing their production). Firms plagued with high structural inertia are more likely to refrain from adaptive moves; consequently, the happen-to-be-fit specimen from the inert set will be over-represented among winners when unpredictable market conditions make rational adaptation impossible.

No belief assumption prevents $B$, however, from seeing scenarios $s_1$, $s_4$, $s_6$, and $s_8$ (Fig. 2). From now on, we focus on these four outcomes. Scenario $s_1$ ($B$ catches up by imitating $A$'s successful M&A move) depicts an adaptive sequence of the *Red Queen* competition observed in many industries (Van Valen 1973; Barnett 2008; Barnett and Sorenson 2002; Barnett and Pontikes 2008). The Red Queen evolutionary theory posits that although surviving species/organizations learn to adapt better with time, the relative positions between survivors will sustain because rivals also adapt in the course of ongoing competition. Table 3 also discloses that while $B$ can count on a middle-of-the road result (0) when opting for imitation ($s_{1,6}$), it believes to have either positive ($s_8$) or potentially negative ($s_4$) relative payoff to $A$ when it withholds, depending on the failure/success of $A$'s M&A move. We assume that $B$ compares the *expected values* of relative payoffs when considering multiple outcomes like $s_{4,8}$. Having no clue if $A$'s M&A move will succeed, $B$ assigns the same subjective probability to $A$'s success ($s_4$) and failure ($s_8$) by default (Assumption 7). In that special case, the expected value is the average of the two payoffs. With these considerations in place, Lemma 3 also follows; see the details in the Appendix.

**Assumption 7** $\mathbf{B}\{p(s_4) = p(s_8)\}$
($B$ *believes* that the probabilities of outcomes $s_4$ and $s_8$ are equal.)

**Lemma 3**

$$\begin{aligned}\mathbf{B}\{Holds(s_{1,6}) &\rightarrow rel.payoff(B) = 0 \wedge Holds(s_{4,8})\\ &\rightarrow rel.payoff(B) = (2rc - fi)/2\}\end{aligned}$$

*($B$ believes that if either scenario $s_1$ or $s_6$ hold (engaging), then $B$'s relative payoff to A is 0, while if $s_4$ or $s_8$ hold (withholding), then $B$'s relative payoff is $\frac{2rc-fi}{2}$.)*

A direct consequence of Lemma 3 is that $B$ expects higher relative payoff for M&A engagement ($s_{1,6}$) than for withholding ($s_{4,8}$) when it believes $fi > 2rc$ to hold. Though this constraint is certainly not satisfied for all possible reorganizations, it is well likely to be satisfied in the given context of investigation. Mergers and acquisitions often take place in high profit margin markets. Note furthermore that even if $fi > 2rc$ would not apply, $B$ still may believe it does. Psychological hypes associated with M&A waves can increase expectations of reaping high benefits in an unrealistic manner while letting managers underestimate the difficulties. The hope that the costs of reorganization occur only once while fitness improvements last for a long time may open the envisioned $fi - rc$ gap even wider. Assumption 3*, a stronger version of Assumption 3, puts forward what may result from such beliefs.

**Assumption 3*** $\mathbf{B}\{fi > 2rc\}$
($B$ *believes* that the value of *fi* fitness advantage of a successful M&A is more than two times larger than the *rc* reorganization costs.)

The extended premise set now implies $B$'s preferences over the four scenarios it perceives. $B$ prefers engaging in M&A ($s_{1,6}$) to withholding ($s_{4,8}$):

**Theorem 3** *(From D3-4, A3*, A4-7)*

$$Prefers(B, s_{1,6}, s_{4,8}).$$

We have taken into account the complete set of possible scenarios and arrived at the same result as the original minimax-regret model with its focus limited to $\alpha$ and $\beta$. All outcomes that suggest withholding from imitation tend to be overlooked by firm $B$, at least when Assumptions 1–7 hold. In situations in which market conditions are unpredictable, costly adaptive moves do not improve fitness probabilities, thus making abstaining the optimal strategy. But once perception bias (Assumptions 1–3, 3*) limits $B$'s consideration set, its rational calculations concerning the scenarios it can see suggest engagement. Finally, the premise set also implies what could be a better choice for $B$, provided that its *fi* and *rc* estimates were correct. A non-biased decision-maker would compare the expected values of 'engage' cases $s_{1,2,5,6}$ and 'withhold' cases $s_{3,4,7,8}$, and would find itself to be better off with the latter:

**Theorem 4** *(from D4, A4-7)*

$$Better\_off(B, s_{3,4,7,8}, s_{1,2,5,6})$$

## 4 Concluding remarks

Merger waves remain a puzzle to most economists, especially since they are characterized by large numbers of failures. Separating beliefs from facts, the logical model developed in this paper helped identifying a dynamics that drives decision-makers towards ungrounded imitative moves, thus clarifying why firms are so willing to undertake mergers that they know have only a small chance for success. In aggregation this may drive markets towards malfunctioning. We investigated the eight possible outcomes in the decision-making framework of which the original minimax-regret argument had covered four. With a modest extension of the premise set, the logical model implied the predictions for the other outcomes as well. After exhausting all possible outcomes, the general conclusion is that choosing for merger/acquisition is the expected decision-maker reaction even if the rational decision would be to abstain from this. Logical formalization is modular in the sense that the elements of the premise set can be modified separately. Taking our model as a basis, experimentation may continue to derive outcomes from alternative sets of premises representing possible alternative interpretations of the natural language theory under investigation. Working with the *Prover9*/*Mace4* theorem prover software (McCune 2011) is quite simple; our theorems and their supporting premises are listed in the required format in Appendix. Thus, with copy/pasting the formulae to the theorem prover, the impact of alternative model specifications can be explored. Does the modification of a given definition or assumption affect the theorems? What sort of new theorems might derive from the new premise set? Most importantly, what is the 'price' of having a particular new theorem in terms of additional model constraints? Experimenting with the premises means experimenting with the underlying theory. Logical formalization, in combination with the use of theorem-prover softwares, allows for a new, interactive way of theory testing and development.

Our results may also contribute to seeing managerial malfeasance in and of organizations differently. Instead of thinking about malfeasance in terms of decision-makers' morally questionable acts, our approach suggests that undesirable organizational behavior may also be a consequence of the setting in which organizations live. Since the precise implications of organizational actions are often largely unknown, organizations—be they firms, investment funds, or private equity partnerships—may end up focusing collectively on investments that do not serve the purpose of wealth creation.

## 5 Appendix

### 5.1 Tables 4, 5 and 6.

**Table 4** Premises on arithmetic operations

Instead of characterizing all properties of multiplication/division (which requires second-order logic), some premises express concrete properties of these operations that we need at the derivation. This ad hoc solution allows staying in the first-order framework

| | |
|---|---|
| A9.1 | $x + min(x) = 0$ |
| A9.2 | $x > y \leftrightarrow x + min(y) > 0$ |
| A9.3 | $x + min(y) > 0 \leftrightarrow 0 > y + min(x)$ |
| A9.4 | $x + 0 = x$ |
| A9.5 | $x + y = y + x$ Addition is commutative |
| A9.6 | $(x + y) + z = x + (y + z)$ Addition is associative |
| A9.7 | $x + x = 2^{*}x$ |
| A9.8 | $x > y \rightarrow x + z > y + z$ |
| A9.9 | $0 > x \rightarrow 0 > x/2$ |
| A9.10 | $(x + x) + (x + x) = 4^{*}x$ |
| A9.11 | $(4^{*}x)/4 = x$ |

**Table 5** Premises on research context

| | |
|---|---|
| A10.1 | $Firm(A) \wedge Firm(B)$ |
| A10.2 | $Scen(A) \wedge Scen(B) \wedge Scen(s_i) \wedge Scen(s_{i,j}) \wedge Scen(s_{i,j,k,l})$ for $i, j, k, l =$ 1, ..., 8 |
| A10.3 | $payoff(x) = f(x) - r(x)$ |
| A10.4 | $rel.payoff(B) = payoff(B) - payoff(A)$ |
| A10.5 | $Fit(x) \rightarrow f(x) = fi) \wedge \neg Fit(x) \rightarrow f(x) = 0$ |
| A10.6 | $ReorgCost(x) \rightarrow r(x) = rc \wedge \neg ReorgCost(x) \rightarrow r(x) = 0$ |
| A10.7 | $fi > 0 \wedge rc > 0$ |
| A10.8 | $Holds(s_{i,j}) \rightarrow Holds(s_i) \vee Holds(s_j)$<br>$Holds(s_{i,j,k,l}) \rightarrow Holds(s_i) \vee Holds(s_j) \vee Holds(s_k) \vee Holds(s_l)$<br>$Composite(s_{i,j}, s_i, s_j) \wedge Composite(s_{i,j,k,l}, s_{i,j}, s_{k,l})$ |
| A10.9 | Composite scenarios' relative payoff is the average of the– equally likely– basic scenarios' relative payoffs<br>$Scen(x) \wedge Scen(y) \wedge Composite(z, x, y) \wedge p(x) = p(y) \wedge$<br>$(Holds(x) \rightarrow rel.payoff(B) = w_1) \wedge (Holds(y) \rightarrow rel.payoff(B) = w_2)$<br>$\rightarrow (Holds(z) \rightarrow rel.payoff(B) = (w_1 + w_2)/2)$ |
| A10.10 | Relative score of a scenario composite of four scenarios of equal subjective probability<br>$Scen(x_1) \wedge Scen(x_2) \wedge Scen(x_3) \wedge Scen(x_4) \wedge$<br>$p(x_1) = p(x_2) \wedge p(x_2) = p(x_3) \wedge p(x_3) = p(x_4) \wedge$<br>$(Holds(x_1) \rightarrow rel.payoff(B) = w_1) \wedge (Holds(x_2) \rightarrow rel.payoff(B) = w_2)$<br>$(Holds(x_3) \rightarrow rel.payoff(B) = w_3) \wedge (Holds(x_4) \rightarrow rel.payoff(B) = w_4)$<br>$\rightarrow$<br>$(Holds(x_1) \vee Holds(x_2) \vee Holds(x_3) \vee Holds(x_4)$<br>$\rightarrow rel.payoff(B) = ((w_1 + w_2) + (w_3 + w_4))/4)$ |
| A10.11 | Composite scenarios inherit the – equal – relative payoffs of their component scenarios<br>$Scen(x) \wedge Scen(y) \wedge Composite(z, x, y) \wedge$<br>$(Holds(x) \rightarrow rel.payoff(B) = w) \wedge (Holds(y) \rightarrow rel.payoff(B) = w)$<br>$\rightarrow (Holds(z) \rightarrow rel.payoff(B) = w)$ |

**Table 6** Modal operator axioms applied at derivations

| | | |
|---|---|---|
| For formulae $\varphi$ and $\psi$: | | |
| A11.1 | $\mathbf{B}\,\varphi \wedge (\varphi \to \psi) \to \mathbf{B}\,\psi$ | Belief reports are closed under logical deduction |
| A11.2 | $\mathbf{B}\,\varphi \to \neg\mathbf{B}\neg\varphi$ | Beliefs are consistent |
| A11.3 | $\mathbf{B}\,\varphi \wedge \mathbf{B}\,\psi \to \mathbf{B}(\varphi \wedge \psi)$ | |
| A11.4 | $\mathbf{B}\,\varphi \to \mathbf{BB}\,\varphi \wedge \neg\mathbf{B}\,\varphi \to \mathbf{B}\neg\mathbf{B}$ | Introspection. Agents are aware of their beliefs |
| A11.5 | $\mathbf{K}\,\varphi \to \mathbf{B}\,\varphi$ | Knowing involves believing what is known |

$\mathbf{B}\,\varphi$ means that the managers of firm *B believe* that $\varphi$ is the case; $\mathbf{K}\,\varphi$ means that they *know* that $\varphi$ is the case

## 5.2 Proofs

We have justified the conclusions of the FOL core of the modal logic formalization with the online available Prover9 theorem prover. Getting to the 'FOL core' involved the following. First, we made two separate premise sets, one for beliefs and one for 'state of affairs' (which two sets can contradict). Second, we removed the modal operators from the formulae. Third, we derived by Prover9 and Mace4 the FOL versions of Theorems 1–3 from the premise set on beliefs, and Theorem 4 from the premise set on 'state of affairs'. Fourth, we re-installed the modal operators to the formulae. The consecutive application of Axioms A11.1–4 (Table 6) to the re-unified premise set subsequently proves the modal logic versions of Theorems 1–3.

#### 5.2.1 The theorems and their premises in Prover9 (FOL) format

```
%THEOREM 1

Holds(alpha) <-> Opts(A) & Fit(A) & -Imitates(B, A) .          %D1
Holds(beta)  <-> Opts(A) & -Fit(A) & Imitates(B, A) .          %D2
Prefers(B, x, y) <-> Better_off(B, x, y).                      %D3
Firm(x) & -Opts(x) -> -Fit(x) .                                %A1
Firm(x) & Firm(y) & Imitates(y,x)
             -> (Fit(x)->Fit(y)) & (-Fit(x)->-Fit(y)) .        %A2
fi > rc .                                                      %A3
Firm(x) -> (Opts(x) <-> ReorgCost(x)).
                                                               %A4
Opts(A) -> (Opts(B) <-> Imitates(B,A)) .                       %A5
Scen(x) & Scen(y) & (Holds(x)->relpayoff(B)=w1) &
(Holds(y)->relpayoff(B)=w2)->((w2>w1)->Better_off(B,y,x))
& ((w2=w1)->Indiff(B,y,x)) .                             %A6

Firm(A) & Firm(B) .                                           %A1.1
Scen(alpha) & Scen(beta) .                               %A1.2
payoff(x) = f(x)+ min(r(x)) .                            %A1.3
relpayoff(B) = payoff(B) + min(payoff(A)) .                   %A1.4
(Fit(x) -> f(x) = fi) & (-Fit(x) -> f(x) = 0) .          %A1.5
(ReorgCost(x)->r(x)=rc) & (-ReorgCost(x)->r(x =0).       %A1.6
x + min(x) = 0 .                                         %A9.1
x > y <-> (x + min(y)) > 0 .                             %A9.2
(x + min(y)) > 0  <-> 0 >(y + min(x)) .                  %A9.3

%Theorem 1
Prefers(B, beta, alpha).

%-------------------------------------------------------


%THEOREM 2

%Scenarios s1-s8.                                       %D4
(Holds(s1) <-> Opts(A) & Fit(A) & Imitates(B,A) & Fit(B)) &
(Holds(s2) <-> Opts(A) & Fit(A) & Imitates(B,A) & -Fit(B)) &
(Holds(s3) <-> Opts(A) & Fit(A) & -Imitates(B,A) & Fit(B)) &
(Holds(s4) <-> Opts(A) & Fit(A) & -Imitates(B,A) & -Fit(B)) &
(Holds(s5) <-> Opts(A) & -Fit(A) & Imitates(B,A) & Fit(B)) &
(Holds(s6)  <-> Opts(A) & -Fit(A) & Imitates(B,A) & -Fit(B)) &
(Holds(s7) <-> Opts(A) & -Fit(A) & -Imitates(B,A) & Fit(B)) &
(Holds(s8) <-> Opts(A) & -Fit(A) & -Imitates(B,A) & -Fit(B)).

Firm(x) & -Opts(x) -> -Fit(x) .                               %A1
Firm(x) & Firm(y) & Imitates(y, x)
      -> (Fit(x) -> Fit(y)) & (-Fit(x) -> -Fit(y)).           %A2
Opts(A) -> (Opts(B) <-> Imitates(B, A)) .                     %A5

Firm(A) & Firm(B) .                                           %A1.1

%Theorem 2
-Holds(s2) & -Holds(s3) & -Holds(s5) & -Holds(s7).

%--------------------------------------------------------
```

```
%THEOREM 3

%Lemma 3.
(Holds(s16) -> relpayoff(B) = 0)  &
(Holds(s48) -> relpayoff(B) = (((2*rc) + min(fi)) / 2)).

Prefers(B,x,y) <-> Better_off(B,x,y) .                   %D3
fi > (2 * rc) .                                          %A3*
Scen(x) & Scen(y) & (Holds(x)->relpayoff(B)=w1) &
(Holds(y)->relpayoff(B)=w2)->((w2>w1)->Better_off(B,y,x))
& ((w2=w1)->Indiff(B,y,x)) .                             %A6

% (Applied to s1,s4,s6,s8,s16,s48)                       %A1.2
Scen(s1) & Scen(s4) & Scen(s6) & Scen(s8) & Scen(s16)
& Scen(s48).
x + min(x) = 0 .                                         %A9.1
x + 0 = x .                                              %A9.4
(x + y) + z = x + (y + z). %Addition is associative.    A9.6.
x > y -> (x + z) > (y + z) .                             %A9.8
0 > x  -> 0 > (x / 2) .                                  %A9.9

%Theorem 3
Prefers(B,s16, s48) .


%----------------------------------------------------


%THEOREM 4

%Lemma 4
(Holds(s1) -> relpayoff(B) = 0 )   &
(Holds(s2) -> relpayoff(B) = min(fi) )   &
(Holds(s3) -> relpayoff(B) = rc) &
(Holds(s4) -> relpayoff(B) = (rc + min(fi)) ) &
(Holds(s5) -> relpayoff(B) = fi) &
(Holds(s6) -> relpayoff(B) = 0) &
(Holds(s7) -> relpayoff(B) = (fi + rc) ) &
(Holds(s8) -> relpayoff(B) = rc) .

Scen(x) & Scen(y) & (Holds(x)->relpayoff(B)=w1) &
(Holds(y)->relpayoff(B)=w2)->((w2>w1)->Better_off(B,y,x))
& ((w2=w1)->Indiff(B,y,x)) .                             %A6

% (Generalized to s1-s8 probabilities)                   %A7
p(s1)=p(s2) & p(s2)=p(s3) & p(s3)=p(s4) & p(s4)=p(s5) &
p(s5)=p(s6) & p(s6)=p(s7) & p(s7)=p(s8).

% (Applied to s1-s8, s1256 and s3478)                          %A10.2
Scen(s1) & Scen(s2) & Scen(s3) & Scen(s4) & Scen(s5) & Scen(s6) &
Scen(s7) & Scen(s8) & Scen(S1256) & Scen(s3478).

fi > 0 & rc > 0 .                                        %A10.7

% (Applied to S1256 and s3468)                           %A10.8
Holds(s3478) -> (Holds(s3)|Holds(s4)|Holds(s7)|Holds(s8)).
Holds(S1256) -> (Holds(s1)|Holds(s2)|Holds(s5)|Holds(s6)).
```

```
% Relative score of a scenario composite of four
%scenarios  of equal subjective probability.              %A10.10
Scen(x1) & Scen(x2) & Scen(x3) & Scen(x4) &
p(x1) = p(x2) & p(x2) = p(x3) & p(x3) = p(x4) &
((Holds(x1)->relpayoff(B)=w1) & (Holds(x2)->relpayoff(B)=w2) &
 (Holds(x3)->relpayoff(B)=w3) & (Holds(x4)->relpayoff(B)=w4))
    ->((Holds(x1)|Holds(x2)|Holds(x3)|Holds(x4))->
                  relpayoff(B)=(((w1+w2)+(w3+w4))/4)).
x + min(x) = 0 .                                        %A9.1
x + 0 = x .                                             %A9.4
(x + y) + z  = x + (y + z). % Addition is associative.  %A9.6
(x + x) + (x + x) = 4 * x .                                    %A9.10
((4*x)/4) = x .                                                %A9.11

%Theorem 4. (Proof may take minutes!)
Better_off(B, s3478, S1256).

%-------------------------------------------------------

% LEMMA 4

%Scenarios s1-s8.                                      %D4
(Holds(s1) <-> Opts(A) & Fit(A) & Imitates(B,A) & Fit(B))   &
(Holds(s2) <-> Opts(A) & Fit(A) & Imitates(B,A) & -Fit(B))  &
(Holds(s3) <-> Opts(A) & Fit(A) & -Imitates(B,A) & Fit(B))  &
(Holds(s4) <-> Opts(A) & Fit(A) & -Imitates(B,A) & -Fit(B)) &
(Holds(s5) <-> Opts(A) & -Fit(A) & Imitates(B,A) & Fit(B))  &
(Holds(s6)  <-> Opts(A) & -Fit(A) & Imitates(B,A) & -Fit(B))&
(Holds(s7) <-> Opts(A) & -Fit(A) & -Imitates(B,A) & Fit(B)) &
(Holds(s8) <-> Opts(A) & -Fit(A) & -Imitates(B,A) & -Fit(B)).

Firm(x) -> (Opts(x) <-> ReorgCost(x)) .                 %A4
Opts(A) -> (Opts(B) <-> Imitates(B, A)) .               %A5

%Premises from Tables A1-2 (Appendix)
Firm(A) & Firm(B) .                                     %A10.1
payoff(x) = f(x)+ min(r(x)) .                           %A10.3
relpayoff(B) = payoff(B) + min(payoff(A)) .             %A10.4
(Fit(x)->f(x)=fi) & (-Fit(x)->f(x)=0) .                 %A10.5
(ReorgCost(x)->r(x)=rc) & (-ReorgCost(x)->r(x)=0) .     %A10.6
(x + min(x)) = 0 .                                      %A9.1
(x + 0) = x .                                           %A9.4
(x + y) = (y + x) . % Addition is commutative.          %A9.5
(x + y) + z  =  x + (y + z). %Addition is associative.  %A9.6


%Lemma 4
%REM Proven by conjucts because of exploding computation time.

(Holds(s1) -> relpayoff(B) = 0)   &
(Holds(s2) -> relpayoff(B) = min(fi) )  &
(Holds(s3) -> relpayoff(B) = rc) &
(Holds(s4) -> relpayoff(B) = (rc + min(fi)) )  &
(Holds(s5) -> relpayoff(B) = fi) &
(Holds(s6) -> relpayoff(B) = 0) &
(Holds(s7) -> relpayoff(B) = (fi + rc) ) &
(Holds(s8) -> relpayoff(B) = rc) .
%-------------------------------------------------------
```

```
%LEMMA 3

%Lemma 4
(Holds(s1) -> relpayoff(B) = 0)  &
(Holds(s2) -> relpayoff(B) = min(fi)) &
(Holds(s3) -> relpayoff(B) = rc) &
(Holds(s4) -> relpayoff(B) = (rc + min(fi))) &
(Holds(s5) -> relpayoff(B) = fi) &
(Holds(s6) -> relpayoff(B) = 0)  &
(Holds(s7) -> relpayoff(B) = (fi + rc)) &
(Holds(s8) -> relpayoff(B) = rc) .

% (Generalized to s1-s8 probabilities)                    %A7
p(s1)=p(s2) & p(s2)=p(s3) & p(s3)=p(s4) & p(s4)=p(s5)
& p(s5)=p(s6) & p(s6)=p(s7) & p(s7)=p(s8).

% (Applied to s1-s8)                                       %A10.2
Scen(s1) & Scen(s2) & Scen(s3) & Scen(s4) & Scen(s5)
& Scen(s6) & Scen(s7) & Scen(s8).

% (Applied to s1,s6,s4 and s8)                            %A10.8
Composite(s16,s1,s6) & Composite(s48,s4,s8) .

%Composite scenarios' rel. payoff is the average of the equally
%likely, basic scenarios' rel. payoffs.                   %A10.9
Scen(x) & Scen(y) & Composite(z,x,y) & p(x) = p(y) &
(Holds(x)->relpayoff(B)=w1) & (Holds(y)->relpayoff(B)=w2)
                 -> (Holds(z)->relpayoff(B)=((w1+w2)/2)).

% Composite scenarios inherit the - equal - rel. payoffs
% of their component scenarios.                          %A10.11
Scen(x) & Scen(y) & Composite(z,x,y) &
(Holds(x)->relpayoff(B)=w) & (Holds(y)->relpayoff(B =w)
                        -> (Holds(z)->relpayoff(B)=w) .

x + 0 = x .                                               %A9.4
(x + y) = (y + x) . %Addition is commutative.             %A9.5
(x + y) + z  =  x + (y + z). %Addition is associative.    %A9.6
x + x = 2 * x .                                           %A9.7


% Lemma 3
(Holds(s16) -> relpayoff(B) = 0)  &
(Holds(s48) -> relpayoff(B) = (((2*rc) + min(fi)) / 2)).

%---------------------------------------------------------
```

### 5.3 Ending the wave

How does the system get out the wave? Most likely: targets become too expensive as market values become exuberant due to explosive activity; and takeover premiums above market value increase along the wave (the number of remaining targets declines with increasing appetite), while real efficiency gains that could fuel ongoing merger behavior remain at bay. Managers gradually adjust their expectations accordingly, thus assigning a higher $p$ subjective probability to failure than before. In model terms, $B$ would only opt for imitation if it expects $fi_B > \frac{rc_B}{1-p}$ to hold. The derivation is as follows. The condition that $s_{1,6}$ (imitating) has higher expected relative payoff than $s_{4,8}$ (withholding) at merger success probability $p$ is expressed

**Table 7** *B*'s relative payoffs in the basic scenarios when *fi* or *rc* can be different for *A* and *B*

| Scenario | $s_1$ | $s_2$ | $s_3$ | $s_4$ | $s_5$ | $s_6$ | $s_7$ | $s_8$ |
|---|---|---|---|---|---|---|---|---|
| *B*'s Rel. payoff | $fi_B - fi_A - rc_B + rc_A$ | $rc_A - rc_B - fi_A$ | $fi_B - fi_A + rc_A$ | $rc_A - fi_A$ | $fi_B - rc_B + rc_A$ | $rc_A - rc_B$ | $rc_A + fi_B$ | $rc_A$ |

as:

$$p(rc_A - rc_B) + (1-p)(fi_B - fi_A + rc_A - rc_B) > p \cdot rc_A + (1-p)(rc_A - fi_A).$$

This gives: $fi_B > \frac{rc_B}{1-p}$. For example, for $p = 2/3$, $3/4$ and $4/5$, satisfying this inequality and so opting for imitation requires that managers expect, respectively, three, four and five times higher fitness benefits than reorganization costs. So expecting high $1-p$ failure probability is likely to block mergers beyond a threshold. Table 7 displays the relative payoff values for the general case when both *fi* and *rc* can differ for *A* and *B*.

Evaporating first-mover advantages may also make *B* realize that benchmarking on successful practices would not likely improve its chances. In model terms, the fitness-facilitating part of belief Assumption 2 would not hold, whilst its claim on the detrimental effect of imitating bad practice would sustain. This change would allow *B* to perceive $s_2$, but not $s_5$, see Figure 2 in the main text. Comparing then *B*'s expected relative payoffs for the perceived $s_{1,2,6}$ (imitation) and $s_{4,8}$ (withholding), and as before keeping scenario probability $p$ the same, reveals that *B* should believe $fi > 6rc$ to hold for choosing imitation rather than abstaining.

## References


Barnett, W.P.: The Red Queen among Organizations: How Competitiveness Evolves. Princeton University Press, Princeton (2008)

Barnett, W.P., Carroll, G.R.: Modeling internal organizational change. Ann. Rev. Soc. **21**, 217–237 (1995)

Barnett, W.P., Pontikes, E.G.: The Red Queen, success bias, and organizational inertia. Manag. Sci. **54**, 1237–1251 (2008)

Barnett, W.P., Sorenson, O.: The Red Queen in organizational creation and development. Ind. Corp. Change **11**, 89–325 (2002)

Bikker, J.A., Haaf, K.: Competition, concentration and their relationship: an empirical analysis of the banking industry. J. Bank. Finac. **26**, 2191–2214 (2002)

Boone, C., Hendriks, W.: Top management team diversity and firm performance: moderators of functional-background and locus-of-control diversity. Manag. Sci. **55**, 165–180 (2009)

Bruggeman, J.P., Vermeulen, I.: A logical toolkit for theory (re)construction. Soc. Methodol. **32**, 183–217 (2002)

DiMaggio, P.J., Powell, W.W.: The iron cage revisited: institutional isomorrvarphism and collective rationality in organizational fields. Am. Soc. Rev. **48**, 147–160 (1983)

Gamut, L.T.F.: Logic, Language and Meaning, Volume 1: Introduction to Logic. Chicago University Press, Chicago (1991)

Gamut, L.T.F.: Logic, Language and Meaning, Volume 2: Intensional Logic and Logical Grammar. Chicago University Press, Chicago (1991)

Granovetter, M.: Threshold models of collective behavior. Am. J. Soc. **83**, 1420–1443 (1978)

Gugler, K., Mueller, D.C., Yurtoglu, B.B.: The determinants of merger waves. Research paper, Utrecht University, School of Economics (2005)

Hambrick, D.C.: Upper echelons theory: an update. Acad. Manag. Rev. **32**, 334–343 (2007)

Hannan, M.T., Freeman, J.: Structural inertia and organizational change. Am. Soc. Rev. **49**, 149–164 (1984)

Hart, S., Mas-Colell, A.: Continuous regret-based dynamics. Games Econ. Behav. **45**, 375–394 (2003)

Herzig, A., Longin, D.: On modal probability and belief. In: Carbonell, J.G., Siekmann, J. (eds.) Symbolic and Quantitative Approaches to Reasoning with Uncertainty. Lecture Notes in Computer Science, pp. 62–73. Springer, Berlin (2003)
Hiller, N.J., Hambrick, D.C.: Conceptualizing executive hubris: the role of (hyper) core self-evaluations in strategic decision-making. Strat. Manag. J. **26**, 297–319 (2005)
Kamps, J., Pólos, L.: Reducing uncertainty: a formal theory of 'Organizations in action'. Am. J. Soc. **104**, 1774–1810 (1999)
Kuilman, J., Vermeulen, I., Li, J.: The consequents of organizer ecologies: a logical formalization. Ac. Manag. Rev. **34**, 253–272 (2009)
Lakatos, I.: Proofs and Refutations. Cambridge University Press, Cambridge (1976)
Lane, C., Bachmann, R. (eds.): Trust Within and Between Organizations: Conceptual Issues and Empirical Application. Oxford University Press, Oxford (1998)
Lieberman, M.B., Montgomery, D.B.: First-mover advantages. Strat. Manag. J. **9**, 41–58 (1988)
McCune, W.: Prover9 and Mace4. Theorem-prover software manual and download. http://www.cs.unm.edu/~mccune/mace4 (2011) Accessed 3 Nov 2014
Nelson, R.R., Winter, S.G.: An Evolutionary Theory of Economic Change. Belknap Press, Cambridge (1982)
Péli, G.: Fit by founding, fit by adaptation: reconciling conflicting organization theories with logical formalization. Ac. Manag. Rev. **34**, 343–360 (2009)
Péli, G., Masuch, M.: The logic of propagation strategies: axiomatizing a fragment of organizational ecology in first-order logic. Org. Sci. **8**, 310–331 (1997)
Pólos, L., Hannan, M.T.: A logic for theories in flux: a model theoretic approach. Logique et Analyse **47**, 85–121 (2004)
Pryor, F.L.: Dimensions of the worldwide merger boom. J. Econ. Issues **35**, 825–840 (2001)
Ruef, M.: Boom and bust: the effect of entrepreneurial inertia on organizational populations. In: Baum, J.A.C., Dobrev, S.D., van Witteloostuijn, A. (eds.) Ecology and Strategy (Advances in Strategic Management, Vol. 23), pp. 29–72. Emerald Group Publishing Limited, Bingley (2006)
Thompson, J.D.: Organizations in Action: Social Science Bases of Administrative Theory. Transaction Publishers, New Brunswick (2003). [1967]
Savage, L.J.: The theory of statistical decision. J. Am. Stat. Assoc. **46**, 55–56 (1951)
Schenk, H.: Bandwagon mergers, international competitiveness, and government policy. Empirica **23**, 255–278 (1996)
Schenk, H.: Mergers and concentration policy. In: Bianchi, P., Labory, S. (eds.) International Handbook of Industrial Policy, pp. 153–159. Edward Elgar, Cheltenham (2006)
Scherer, F.M.: A new retrospective on mergers. Rev. Ind. Org. **28**, 327–341 (2006)
Schlag, K., Zapechelnyuk, A.: On the impossibility of achieving no regrets in repeated games. J. Econ. Behav. Org. **81**(1), 153–158 (2010). doi:10.1016/j.jebo.2011.09.014
Simon, H.A.: A behavioral model of rational choice. Quart. J. Econ. **69**, 99–118 (1955)
Town, R.J.: Merger waves and the structure of merger and acquisition time-series. J. Appl. Econometr. **7**, 83–100 (1992)
Veltman, F.: Defaults in update semantics. J. Phil. Logic **25**, 221–261 (1996)
Van Valen, L.: A new evolutionary law. Evol. Theory **1**, 517–547 (1973)
Watts, D.J.: A simple model of information cascades on random networks. PNAS **99**, 5766–5771 (2002)