

# A Theory of Explicit Strategy

WORKING PAPER – IN PROGRESS

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## Abstract

This paper studies the nature and structure of strategy (in its everyday sense), starting from a (functional) definition of strategy as ‘*the smallest set of (core) choices to optimally guide the other choices.*’ This definition captures the idea of strategy as the core of a – potentially flexible and adaptive – intended course of action. It coincides with the equilibrium outcome of a ‘strategy formulation game’ where a person can – at a cost – look ahead, investigate, and announce a set of choices to the rest of the organization.

Starting from that definition, the paper studies what makes a decision ‘strategic’ and what makes strategy important, considering the ability to commit, irreversibility and persistence, the presence of uncertainty (and the type of uncertainty), the number and strength of interactions and the centrality of a choice, the level and importance of a choice, the need for specific capabilities, competition, and dynamics. It shows, for example, that irreversibility does not make a decision more strategic but does make strategy more valuable, that long-range strategies will be more concise, why a choice what *not* to do can be very strategic, and that a strategy ‘bet’ can be valuable. It also shows how understanding the structure of strategy may enable a strategist to develop the optimal strategy in a very parsimonious way.

JEL Codes: D70, L20, M10

## 1 Introduction

Judging from the more than 70,000 management books on the topic (Kiechel 2010), strategy is an issue of great interest to business. But the importance of strategy – in its everyday meaning – goes beyond business: a central bank needs a strategy to fight a financial crisis, a health agency needs a strategy to fight an epidemic, and the military needs a strategy to win a war. But what makes a decision strategic? How do you determine whether some set of decisions constitutes a strategy? And why does strategy matter? The existing definitions in the literature – such as Andrews’ definition as ‘the goals of the firm and the pattern of policies and programs designed to achieve those goals’ – provide little concrete guidance on these foundational questions. But the questions really matter:

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\*HBS (evandensteen@hbs.edu). This paper benefitted enormously from the discussion by, and many conversations with, John Roberts and from the feedback and insights of Bob Gibbons. This paper would also not have existed without my HBS Strategy colleagues and without my students, who both made me think deep about strategy (from very different angles) and provided (resp. explicit and implicit) feedback on the ideas. I need to thank especially Juan Alcacer, Bharat Anand, Ramon Casadesus-Masanell, David Collis, and Jan Rivkin for many conversations that influenced my thinking on this issue. I also thank Jim Dana, Joshua Gans, Hanna Halaburda, Tarun Khanna, Hongyi Li, John Matsusaka, Michael Powell, Birger Wernerfelt, Tim Van Zandt, Todd Zenger, and the seminar participants at the LSE, MIT, NBER Organizational Economics, NYU, University of Michigan, University of Rochester, University of Toronto, USC, Washington University, Washington University’s ‘Foundations of Strategy’ conference, and the HBS Strategy brown bag lunch for their comments and suggestions. An earlier version of this paper circulated under the name ‘A Theory of Explicitly Formulated Strategy’. This paper and ‘The role of leaders in strategy formulation’ are respectively the first and second part of the earlier working paper ‘A Theory of Strategy and the Role of Leaders in it.’ IMPORTANT NOTE: The paper’s model is in the process of being modified. This may temporarily have introduced some inconsistencies that have not yet been cleaned up.

How do you find a strategy if you don't know what you're looking for? And why would you look for one if you don't know why it matters?

The purpose of this paper is to develop a formal economic theory of strategy<sup>1</sup> that reflects existing ideas in the management literature but that is formalized in a way that permits analysis and an easy and practical interpretation. The analysis explores the foundational questions what makes decisions strategic and what makes strategy more important, considering a range of factors such as commitment, uncertainty, irreversibility, the level of a decision, and more. While motivated by a business setting, the paper studies a generic project so that the ideas apply more broadly, though some sections will focus on competitive strategy.

A theory of strategy needs to build on a clear definition of strategy. The definitions common in the literature, however, are mostly *descriptive* ('what strategy looks like'), which makes them hard to use for analysis.<sup>2</sup> I therefore start from a functional definition ('what strategy does') as '*the smallest set of (core) choices to optimally guide the other choices.*'<sup>3</sup> This definition captures the idea that strategy is the core of a – potentially flexible and adaptive – intended course of action and that it provides each decision maker with just enough guidance and with just enough of the full picture to ensure consistency across decisions. Note that strategy, so defined, generates *endogenously* a hierarchy of decisions, with more 'strategic' decisions guiding subordinate decisions. (In equilibrium, the strategic choices will turn out to be, among other things, high-level choices, such as the choice of product scope or target customer.) Developing a functional definition rather than starting from the existing descriptive ones is key to this analysis.<sup>4</sup>

A good way to motivate this definition is to ask what characterizes an 'absence of strategy'. When people say (or complain) that 'this organization lacks a strategy' they usually mean that the organization took a number of actions that each made sense on its own but that did not make sense together, i.e., that lack a unifying logic. Strategy thus ensures, like a plan, that all decisions fit together. This fits with the Oxford Dictionaries Online definition of strategy as 'a plan of action designed to achieve a long-term or overall aim' and Mintzberg's (1987) statement that 'to almost anyone you care to ask, *strategy is a plan* [emphasis in original] – some sort of consciously intended course of action, a guideline [...]'.<sup>5</sup> But a strategy is *not* a detailed plan of action; it is a plan of action boiled down to its most essential choices and decisions. That leads to this definition as 'the smallest set of choices to optimally guide the other choices.'

The paper then first observes – and shows – that this definition of strategy coincides with the equilibrium outcome of a game that captures a typical ('planned') strategy process – as we often see it in a consulting team or in a firm – where someone takes a step back, collects information, and designs an overall plan for the organization. The model captures, in particular, a project where a group of people each make a choice that affects the project. Each person has only 'local' information about her own decision and interactions with others, but knows little or nothing about the others' decisions. Without a strategist, this would result in the piecemeal outcome, characteristic of a 'lack of strategy': each decision is optimal on a standalone basis but there is a lack of alignment across decisions. The analysis then considers the effect of allowing one person (conveniently called

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<sup>1</sup>In the body of the paper, I will use the term 'strategy' always in its everyday sense, rather than its game-theoretic sense. Whereas the proofs use both meanings, it will be clear from the context which meaning is intended.

<sup>2</sup>It's like defining 'a gun' by describing it without mentioning that it is 'something to shoot with'.

<sup>3</sup>The term 'optimally' reflects the need to consider dynamics, flexibility, and cost-benefit trade-offs. This definition is also useful for practice and educational purposes (Van den Steen 2012a).

<sup>4</sup>

<sup>5</sup>Mintzberg (1987) goes on to provide 9 other perspectives on strategy. The current paper, however, takes intentionally the perspective of 'almost anyone you care to ask,' to cite Mintzberg.

‘the strategist’) to collect information – at a cost – and announce a set of choices or decisions. In equilibrium, this person will announce exactly a ‘strategy’ as defined above. By linking the definition of strategy to a concrete process, this connection provides a transparent basis for the formal analysis and provides micro-foundations.

The main body of the paper then analyzes the structure and importance of such a strategy. Which decisions will be strategic – i.e., within this *endogenous* hierarchy of decisions, which decisions will guide others? And when is strategy most important?

The first set of results is that decisions with a large number of strong interactions are more strategic – and make strategy more valuable – especially if those decisions’ interactions do not overlap with those of other strategic decisions. The intuition is that such choices can provide effective guidance for many other choices at once. A key implication of this result is that both more *central* decisions and, more importantly, *higher-level* decisions will be more strategic. This fits the casual observation that effective strategies tend to specify high-level central choices, such as scope and distinctive value proposition. The result on overlap implies that a company’s strategy will often specify one or two choices per business function (such as marketing or production).

I then turn to the role of persistence, commitment, and irreversibility in strategy. These matter not only for their practical relevance but also because commitment and irreversibility are one of the few, if not the only, characteristics that have been explicitly identified in the management literature as making a decision strategic, in particular in Ghemawat’s (1991) seminal work. The paper carefully defines each of these characteristics and then shows the following:

- Irreversibility does not necessarily make a decision more strategic, and may make it even less strategic. But it always increases the value of strategy. And it makes decisions with which that decision interacts more strategic.
- Persistence makes decisions more strategic. One implication is that, in volatile environments, it is often optimal to build a strategy around internal factors that are more under the control of the firm, such as resources or capabilities. Another implication is that longer-term strategies will be more concise.
- The ability to commit may make a decision more strategic, but only when there are no other drivers of persistence. Automatic commitment (upon announcement) may actually make a decision less strategic.

I will discuss how these results confirm some of Ghemawat’s (1991) insights but also differ on others.

I then consider the effects of uncertainty. Intuitively, uncertainty seems to make strategy both more valuable (because it gives direction in the face of uncertainty) but also less valuable (because uncertainty makes it more difficult to get the strategy right). The formal analysis shows that it is important to distinguish two kinds of uncertainty. First, *prior* uncertainty – uncertainty before the strategist investigates – makes a choice more strategic and strategy more valuable, *if* that choice also has strong interactions. This complementarity shows that uncertainty matters here *not* because uncertainty makes it difficult to find the right decision, but because uncertainty makes it hard to predict what others will do and thus to align. One important implication is that high-level generic choices, such as ‘maximize shareholder value’ or ‘be the preferred service provider’ are not good strategic choices because there is little uncertainty about them (unless they go against the expected direction). Another important implication is that choices what *not* to do can be very strategic as they often convey a lot of information. Second, *residual* uncertainty – after the state and interactions have been investigated – makes a choice less strategic and reduces the value of

strategy. The best strategic choices have clear implications. I also show that a ‘strategic bet’ – where a company commits to a strategy despite facing very high uncertainty – may be valuable, especially when internal alignment is important. This fits the observation that high-tech firms often talk in terms of strategic bets.

The paper further shows that strategy may also improve investments in resources or capabilities that are specific to a particular course of action. The reason is that strategy makes clear which investments will pay off. Hence, choices on which such investments depend are more strategic and strategy is more valuable in the presence of such specific investments.

I also illustrate how the model can be used for analyzing competitive strategy and strategy dynamics. With respect to competitive strategy, the analysis shows that decisions may be more *or less* strategic when they influence competitors’ actions, depending on the direction of the influence. Choices about strategic complements are more ‘strategic’ (in this sense) than choices about strategic substitutes. The model also helps to identify ‘strategic rivals,’ i.e., competitors that must be endogenized in a strategic analysis. With respect to dynamics, the model shows that optimal strategy will often be dynamic but that learning may make a choice both more *or less* strategic.

A final important insight is that understanding the structure of strategy may enable a strategist to find the optimal strategy without a comprehensive optimization and that such strategy can be very parsimonious. In particular, in a simple example with 100 choices where all choices interact equally with each other, the strategist only investigates up to 4 or 5 states when investigation is free, and even less when it is costly, and announces these choices as the strategy. In fact, when all players have a common objective, a strategy that investigates just *one* state and announces *one* choice is sufficient for this setting. This shows how strategy can be a very effective tool to find and give direction to an organization.

This perspective on strategy also has implications for leadership and for organization design. With respect to leadership, strategy as defined here is also – in some very precise sense – the smallest set of decisions that needs to be decided centrally to get consistency, tying this definition of strategy back to its etymological origin as the decisions that need to be under the authority of the leader or the overall commander. In a companion paper, Van den Steen (2012b) builds on this analysis to explore the role of people and leaders in strategy formulation: how does it matter *who* develops the strategy. From an organization design perspective, it is of particular interest that strategy creates *endogenously* a tree-like hierarchy out of an essentially horizontal network of choices. Hence, I conjecture that the drivers that make a decision strategic may also be drivers of hierarchy and organization design.

**Literature** The economics literature closest to this paper is probably Milgrom and Roberts’ (1992) insightful, though informal, discussion of how coordination through strategy and coordination through prices differ. Their discussion of the Hurwicz criterion is also related to some of the ideas in this paper. But they do not formally define strategy or study the nature of strategy, i.e., what decisions are strategic, or what determines the value of a strategy.

Also closely related within the economics literature is a stream of research on the organizational effects of specific strategy choices. This literature does not define strategy but equates it implicitly with a choice of direction by the manager and then studies how specific choices may be optimal. Rotemberg and Saloner (1994, 1995) show that a narrow strategy – equated with favoring certain projects – can provide incentives for effort and reduce conflict. Zemsky (1994), which is closest to this paper and discussed in Section 4, shows that a commitment to a strategy – equated with a choice of project – can create incentives for investments in skills. Mailath, Nocke, and Postlewaite

(2004) show that human capital specific to a strategy – equated with a choice of business – may, for example, make mergers unattractive.<sup>6</sup> All these papers differ in a number of ways from the current paper. First, these papers do not – either formally or explicitly – define strategy, but equate it with a choice of direction.<sup>7</sup> Equating strategy with a CEO’s choice of direction raises the issue that most of a CEO’s choices (of direction) are quite trivial and not at all considered strategic. Second, and closely related, no paper considers the nature of strategy – i.e., which decisions are strategic – or comparative statics on what makes strategy important. Instead, these papers focus on demonstrating *in principle* a benefit of having a (particular kind of) strategy. But all papers are consistent with this paper in the sense that their insights could be derived in a variation on the model of Section 2.

In the management literature, studies of what makes a decision strategic are very limited. The seminal work of Ghemawat (1991) on irreversibility and commitment will be discussed in more detail in Subsection 4.2, in particular how the results here confirm some predictions but contradict others. In his discussion, Ghemawat (1991) actually points out that even von Clausewitz (1833) side-stepped the question which decisions are strategic by referring to ‘common usage.’ The other related contributions are experience-based lists or rules of thumb on what elements should be specified as part of a strategy, such as Andrews (1971), Bower et al. (1995), Saloner et al. (2001) and Collis and Rukstad (2008), which will be discussed in detail Section 3 when relating this definition to the literature. The fact that Collis and Rukstad (2008) received one of the most coveted awards in the business press, illustrates the importance and need for insight on the question what makes a decision strategic.

The general management literature on strategy, such as Andrews (1971) or Porter (1980), often defines strategy but not in a way that is conducive to a formal analysis. Section 3 shows how this paper formalizes key elements of these definitions. Moreover, some of the results, such as the importance of interactions, relate to ideas suggested in the management literature, as I will discuss.

The more academic management literature on strategy, such as Bower (1970), Mintzberg and Waters (1985), Hambrick and Mason (1984), Levinthal (1997), Rivkin and Siggelkow (2003), has mainly focused on the process by which strategy takes shape in organizations, with particular attention to the non-planned and non-analytical aspects. The current paper complements this literature: Instead of researching how the actual processes deviate from ‘strategy as deliberate planning’, it takes that idea and fleshes it out, yielding complementary insights for strategy. Finally, while different in approach and focus, the discussions of strategy in Ghemawat (1991) and Casadesus-Masanell and Ricart (2010) raised many of the questions that I study in this paper.

From a more structural perspective, this paper is also related to the team theory literature (Marschak and Radner 1972, Geanakoplos and Milgrom 1991, Radner and Van Zandt 1992, Garicano

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<sup>6</sup>More indirectly related is the economic literature on vision and leadership, as vision and strategy are closely related (Rotemberg and Saloner 2000). This literature also often informally refers to a choice of direction as ‘a strategy’ (Rotemberg and Saloner 2000, Van den Steen 2001, Bolton, Brunnermeier, and Veldkamp 2012). Rotemberg and Saloner (2000) showed that vision could improve *incentives for effort* and discussed the relationship between vision and strategy. Most relevant to the current paper, because of their focus on direction setting and coordination, are Van den Steen (2001, 2005) – which showed that vision could give a firm *direction* and *coordination* and also discussed the relationship between vision and strategy – and Hart and Holmstrom (2002), Van den Steen (2010), and Bolton, Brunnermeier, and Veldkamp (2012) – which all developed theories of the effect of vision on coordination and also sometimes refer to a choice of direction as a strategy. Starting with Brandenburger and Stuart (1996), there is also a small but growing literature on ‘competitive advantage,’ which is a central concept for strategy, but it is not focused on the nature or role of strategy itself.

<sup>7</sup>Rotemberg and Saloner (2000) is even the only one to explicitly motivate their use of the term ‘strategy’, pointing out that their model results in some ‘pattern of decisions,’ consistent with Andrews’ definition of strategy.

2000, Dessein and Santos 2006, Dessein, Galeotti, and Santos 2012) as the results are derived in both a team theory model and an agency model. In particular, this paper suggests strategy as an alternative solution to team theory problems. But the double approach implies that team theory is not a fundamental feature. Moreover, there are also some important differences with the existing literature, such as the fact that investigations can be dynamic, that it studies a different setting, and that it focuses on different characteristics. Van den Steen (2012c) discusses this in more depth.

The contribution of this paper is to develop a formal theory of strategy, focused on what makes decisions strategic and what makes strategy important. In doing so, it derives new results and insights on the nature and role of strategy and also develops a functional definition of strategy that permits formal analysis and that clearly distinguishes between a strategy and either a full plan or just a set of important decisions.

The next section describes the model, whereas Section 3 discusses the definition of ‘strategy,’ relates it to the literature, and shows that it is the equilibrium outcome of that model. Section 4 studies what decisions are strategic and the value of strategy. Section 5 discusses and concludes. All proofs are in Appendix A.

## 2 Model

This paper studies a setting in which a group of people are engaged in a common project and must make (sequential or simultaneous) choices that affect the project’s outcome. The basic research question is the nature, properties, and value of ‘a strategy’ (in the everyday sense of the word).

Formally, consider a project that generates revenue  $R$ , which depends on  $K$  decision choices  $\{C_1, \dots, C_K\}$ . Each decision choice  $C_k$  selects a course of action from an infinite set  $\mathcal{C}_k$  of alternatives, i.e.,  $C_k \in \mathcal{C}_k = \{c_k^1, \dots, c_k^f, \dots\}$ .<sup>8</sup> The project revenue  $R$  will depend *both* on whether the choices are correct by themselves (on a standalone basis) *and* on whether the choices *align* correctly. With respect to  $C_k$  being correct on a standalone basis, there is a finite subset  $T_k \subset \mathcal{C}_k$  of  $N \geq 1$  alternatives that are correct (and the others are wrong): choice  $C_k$  is correct if and only if  $C_k \in T_k$  and it is wrong otherwise. With respect to  $C_k$  and  $C_l$  aligning correctly, there is for each  $C_k$  alternative  $c_k^f$  a set of  $N$  pairs  $(c_k^f, c_l^h)$  that are correct (and the others are wrong) – and analogously for each  $C_l$  alternative  $c_l^g$ . Let  $T_{k,l} \subset \mathcal{C}_k \times \mathcal{C}_l$  be the subset of all such pairs, i.e.,  $C_k$  and  $C_l$  are aligned correctly iff  $(C_k, C_l) \in T_{k,l}$ . I will refer to the  $T_k$  and  $T_{k,l}$  as respectively choice states and interaction states and use  $\mathcal{T}_k$  and  $\mathcal{T}_{k,l}$  for the sets of all possible states. The revenue  $R$  is then an increasing function of the choices being correct on a standalone basis and of the choices interacting correctly. In particular, the project revenue has the following parametric form:

$$R = \sum_{k=1}^K \alpha_k I_k + \sum_{k=1}^K \sum_{l=1}^{k-1} \gamma_{k,l} I_{k,l}$$

where  $I_k = I_{C_k \in T_k}$  is the indicator function whether choice  $C_k$  is correct,  $\alpha_k > 0$  is the parameter that measures the importance of the choice being locally correct,  $I_{k,l} = I_{(C_k, C_l) \in T_{k,l}}$  is the indicator function whether the choices  $C_k$  and  $C_l$  are aligned correctly, and  $\gamma_{k,l}$  measures the importance of the interaction. In its simplest form,  $\gamma_{k,l}$  is just a fixed exogenous parameter with  $\gamma_{k,l} \geq 0$ . I will,

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<sup>8</sup>Formally, I will assume – when necessary – that  $\mathcal{C}_k$  has  $M$  elements with  $M \rightarrow \infty$ . The results for an alternative case with  $K > 2$  and  $M = 2$  are available from the author. Results for  $K = 2$  and  $M = 2$  can be found in Van den Steen (2012c). If  $N = 1$ , then  $T_k$  is one choice that is correct and  $T_{k,l}$  is simply a bijection between  $\mathcal{C}_k$  and  $\mathcal{C}_l$ . One way to construct  $T_{k,l}$  is by taking the union of  $N$  bijections.

however, discuss later a more general form to capture the fact that high performance sometimes requires *simultaneously* a good local choice *and* alignment of other decisions on that choice. The interaction states  $T_{k,l}$  capture what is often called ‘internal alignment’ while the choice states  $T_k$  capture ‘external alignment’ (e.g. Bower et al. (1995)). The choice labels  $c_k^f$  are arbitrary and have no particular meaning or order. For example, nothing would change if the  $\{c_k^1, \dots, c_k^f, \dots\}$  labels on some particular choice were permuted and/or renamed to  $\{x_k^1, \dots, x_k^f, \dots\}$ .

The project – consisting of the set of  $K$  decisions and  $K!$  potential interactions – is partitioned into  $K$  (decision) tasks  $Z_k$ , each containing one decision  $C_k$  and a number of its interactions. For each such task, there is a project participant  $P_k$  who is responsible for that task:  $P_k$  makes the choice  $C_k$ , with each participant having at most one task. Apart from these  $K$  project participants, there will also be a strategist  $S$  whose role is discussed below and whose objective is to maximize the total payoff.

All players, including  $S$ , know the parameters  $\alpha_k$  and  $\gamma_{k,l}$ , but have initially – at the start of the game – no knowledge of the states  $T_k$  or  $T_{k,l}$ . In particular, each player starts with a prior belief that the  $T_k$  and  $T_{k,l}$  are independent random draws from the sets of all possible states  $\mathcal{T}_k$  and  $\mathcal{T}_{k,l}$  with all states being equally likely.<sup>9</sup> (Section 4 will study the effect of public/initial information by introducing an up-front public signal about one of the choice states.) The empirical probability distribution of the states and interactions is also that each of the possible states is equally likely. The players thus happen to have a common prior belief that moreover happens to be the true empirical distribution. Van den Steen (2012b) – which studies how it matters *who* the strategist is – allows for differing priors, which seems appropriate for settings where strategy matters. Whereas all players start with uninformative priors, each project participant  $P_k$  will get – in the course of the game per the timing below – *local* information about his choice. In particular, each participant  $P_k$  gets a signal  $\theta_k \in \mathcal{T}_k$  for his own choice state  $T_k$  that is correct with commonly known probability  $p_k > .5$  (and completely uninformative otherwise). Each participant  $P_k$  also gets a signal  $\theta_{k,l} \in \mathcal{T}_{k,l}$  for each of the interactions that are part of his task, with each signal being correct with respective probability  $p_{k,l} \geq .5$ . But  $P_k$  does not get any (direct) signal about any other choice state  $T_l$  ( $l \neq k$ ) or about any other interaction states  $T_{l,m}$ .<sup>10</sup> (If he makes no relevant inference from the strategist’s announcements, then  $P_k$  thus keeps his prior beliefs about these  $T_l$  and  $T_{l,m}$ .) Let  $\theta = (\theta_k; \theta_{k,l})_{k,l \in K, l < k}$  denote the vector of all potential signals.

If the strategist  $S$  – in the course of the game per the timing below – decides to investigate a choice state  $T_k$  (resp. an interaction state  $T_{k,l} \in Z_k$ ), she gets a signal  $\tau_k$  (resp.  $\tau_{k,l}$ ) that is a garbling of  $\theta_k$  (resp.  $\theta_{k,l}$ ) and correct with probability  $q_k$  (resp.  $q_{k,l}$ ). In particular, for  $T_{k,l} \in Z_k$ ,  $\tau_k$  and  $\tau_{k,l}$  equal  $\theta_k$  and  $\theta_{k,l}$  with probability  $1 - \Delta_k$  and are completely random with probability  $\Delta_k$ . This garbling can capture either the fact that local decision makers have more information or, more importantly, that the underlying state – and thus the optimal choice – can change over time (given that the participant gets his signal after the strategist does). As with the signals  $\theta$ ,  $P_k$  (and only  $P_k$ ) also observes  $S$ ’s signals about his task  $Z_k$ .<sup>11</sup>

The timing of the game is indicated in figure 1. At the start of the game, the strategist decides which choice or interaction states to investigate. If the strategist investigates some choice state  $T_k$  (resp. some interaction state  $T_{k,l}$ ), she thus gets the signal  $\tau_k$  (resp.  $\tau_{k,l}$ ) about that state. After

<sup>9</sup>Formally,  $\#C_k = M \rightarrow \infty$ . Hartigan (1983) showed that improper priors are consistent for conditional (probability) statements.

<sup>10</sup>The results would not be affected, but the analysis more involved, if  $P_k$  observed all his interactions  $T_{k,l}$ .

<sup>11</sup>All that matters for the proofs is whether  $P_k$  is aware that the signal may have changed since  $S$  observed it. The alternative that the participant is not aware of any changes gives very similar results but with added complexity.

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<p>Strategy formulation</p> <p>a The strategist decides which states <math>T_k</math> and <math>T_{k,l}</math> to investigate.</p> <p>b When she investigates a state <math>T_k</math> or <math>T_{k,l}</math>, the strategist receives a signal <math>\tau_k</math> or <math>\tau_{k,l}</math> that is correct with probability respectively <math>q_k</math> and <math>q_{k,l}</math>. She can then either return to 1a or continue to 1c.</p> <p>c The strategist can announce a set of choices <math>C_k</math>.</p>	<p>Strategy implementation</p> <p>a Each participant <math>P_k</math> receives the signals <math>\theta_k</math> and <math>\theta_{k,l}</math> about (only) the choice state <math>T_k</math> and interaction states <math>T_{k,l}</math> of her task. These signals are correct with respective probabilities <math>p_k</math> and <math>p_{k,l}</math>.</p> <p>b Each participant makes his or her choice (sequentially without observing others' choices or simultaneously).</p> <p>c Payoffs are realized.</p>

Figure 1: Timing of basic game

receiving the signal, she can decide whether to investigate another state, and so on, or to continue. The cost of investigating  $I$  states is  $c_I(I)$ , with  $c_I(\cdot)$  a strictly increasing function. Based on the signals from all investigations, the strategist can then announce, through cheap talk and at no cost, one or more choices.<sup>12</sup>

In stage 2a of the game, each participant  $P_k$  gets his or her local information (i.e., the  $\theta_k$  and  $\theta_{k,l}$  signals). In stage 2b, all participants then make their choices. To capture the setting of a large organization, participants are assumed to make their choices either simultaneously or sequentially without observing each others' choices. (All major results seem to go through for a model with sequential choices that are publicly observed, though that fits less for large organizations.) In stage 2c, payoffs are realized.

I will assume here that each participant  $P_k$  tries to maximize the payoff from her task  $Z_k$ ,  $\Pi_k = \alpha_k I_k + \sum_{T_{k,l} \in Z_k} \gamma_{k,l} I_{k,l}$ , which is equivalent to assuming that  $P_k$ 's utility is a strictly increasing function of  $\Pi_k$  and that players are risk neutral. (An alternative (in progress) assumes instead that all players, including  $S$ , are cooperating on the same project and share the same objective.) The strategist's objective is to maximize overall project payoff  $R - c_I(I)$ . To break indifference – which considerably simplifies the propositions and proofs without affecting the essential results (and obviously only matters in a set of measure zero) – I will assume that upon indifference, any player prefers the payoff that contains the lowest indexed  $\alpha$  and when still indifferent prefers the payoff that contains the lowest ‘sum of indices’ of  $\gamma$ . I will use  $\succ$  and  $\prec$  to indicate these preferences.

I will focus in the analysis on pure strategy equilibria that are locally symmetric: when permutating the (arbitrary) labels on a choice (and on all its interactions), the labels for that choice are also permutated in the equilibrium. The local symmetry condition ensures that the equilibrium does not depend on a particular labeling and is robust to arbitrary labels. This property could be endogenized as part of the game but at the cost of considerable additional notation and complexity. Note that this does *not* affect the equilibrium itself: it is a traditional Bayesian-Nash equilibrium.

To ensure the existence of a pure strategy equilibrium in this model – that has many decisions and investigations, that has agency incentives but no commitment, and that has a general interaction structure – I need to avoid a matching pennies or rock-papers-scissors equilibrium issue by imposing an extra parametric condition. (Alternatively, using a team theory model, allowing the strategist to commit, or simplifying along other dimensions, would eliminate the need for this assumption. This observation is very important as it shows that this assumption is *not* what drives the results.)<sup>13</sup> I

<sup>12</sup>All results hold if there was a cost of announcing choices. I will, however, state the results as if the cost is zero to make clear that the results are not driven by the cost of announcing.

<sup>13</sup>I conjecture that all results hold without this condition, but mixed equilibria in a game of almost unlimited complexity make things intractable. All essential results have been proved without any conditions and with  $M = 2$  both for  $K = 2$  and for  $I = 1$ .

will, in particular, impose an assumption to exclude (for this version of the model) ‘*strong* loops’: there is no closed loop sequence of choices such that *each* decision *strictly* prefers to align with the next over making its optimal local choice. Formally, there does not exist a sequence of distinct choices  $(C_k, \dots, C_l)$  such that  $\gamma_{k,l}(2p_{k,l} - 1)(1 - \Delta_l) > \alpha_k(2p_k - 1)$  and  $\gamma_{m,n}(2p_{m,n} - 1)(1 - \Delta_m) > \alpha_n(2p_n - 1)$  for each  $C_m$  and  $C_n$  where  $C_n$  follows  $C_m$  in the sequence. This does not exclude loops per se, only *strong* loops where the strict inequality holds for *each* step. If such strong loop exists, it may lead to a matching pennies setting where each tries to outguess the other.

I will finally use some recurring notation throughout the paper. Let  $\beta_k = \alpha_k(2p_k - 1)$  and  $\eta_{k,l} = \gamma_{k,l}(2p_{k,l} - 1)$  combine, for respectively the decision and the interaction states, the importance with the eventual confidence. Let  $t_k^k$  denote the piecemeal choice for  $C_k$ , i.e., the choice that maximizes  $I_k$  according to  $P_k$ ’s beliefs. Define the ‘piecemeal outcome’ or ‘trivial outcome’ as the outcome where each player chooses  $t_k^k$ . Let  $\Gamma_k = \{\gamma_{k,l} : k \in Z_l\}$  denote the set of all interactions guided by  $C_k$ , which I will call the ‘inbound’ interactions for  $C_k$ .

**Variations** In the analysis, I will sometimes consider variations on the basic model to study specific effects, such as the role of specific investments, of commitment, or of irreversibility. While each variation will be discussed at the time of analysis, it is useful to preview them here already.

- To study the role of specific investments, I will allow in some of the analysis that some (additional) participants can make investments that pay off only if the firm follows a specific course of action. For example, cost-reduction know-how only fully pays off if the company follows a cost-focused strategy.
- To study the role of commitment, I will allow in some of the analysis that  $S$  can fix, at the end of stage 1, some of the choices announced in 1c at a cost of  $c_C$  per commitment.
- To study the effect of irreversibility, I will allow in some of the analysis that some participants can reverse their respective choice  $C_k$  after observing others’ choices.
- To study the effect of uncertainty, I will assume in some of the analysis that there is a public signal about one decision – which thus reduces the ex-ante uncertainty about that decision.
- To study the role of competition, I will consider a setting where some of the choices are not part of the project, but part of a competing firm with, obviously, a different objective.

Moreover, as mentioned before, the results will be derived for a slightly more general payoff structure, to capture the fact that a high payoff from a good choice may materialize only if other choices align on it. To that purpose, let for  $T_{k,l} \in Z_k$ ,  $\gamma_{k,l} = \tilde{\gamma}_{k,l} + \check{\gamma}_{k,l}\Pi_l$  with both  $\tilde{\gamma}_{k,l}, \check{\gamma}_{k,l} \geq 0$  exogenous parameters. In this case, some part of the payoff from  $C_l$  (namely  $\check{\gamma}_{k,l}\Pi_l$ ) gets realized only when  $C_k$  aligns correctly on  $C_l$ . The size of  $\check{\gamma}_{k,l}$  then captures the degree to which the full realization of  $\Pi_l$  depends on  $C_k$  also aligning correctly on it.

### 3 Strategy: Definition and Equilibrium Outcome

As this paper’s definition of strategy is central to the analysis, it is useful to motivate and clarify it in some more detail. The purpose of this section is therefore fourfold: 1) clarify important aspects of the definition, 2) concisely relate this paper’s definition to the existing strategy literature, 3) formalize the definition in the context of the game of Section 2, and 4) show that such a strategy is

indeed the equilibrium outcome of the game. (The main body of the paper – outside the proofs – does not need the level of detail and formalism that is developed in the latter 2 parts. The informal definition of strategy and the statement of Observation 1 suffice.)

Let me thus start with some observations and clarifications that are important for the further discussion. First, Subsection 4.1 shows that the ‘choices’ that make up the strategy will typically be relatively broad and high-level choices, because such decisions generate the smallest set to give full guidance. Very narrow choices such as ‘a price of \$249’ require a lot of choices to give full guidance. The high-level choices in strategy – such as ‘being low-cost’ – often function as objectives for lower levels of the organization (Simon 1947), which helps to relate this definition to the literature. At the same time, though, Subsection 4.3 also shows that very generic choices such as ‘be the preferred solution provider’ or ‘maximize shareholder value’ are typically *not* strategic because they do not resolve any uncertainty and thus fail to give any real guidance. A second and closely related observation is that the players in this model can also be interpreted as parts of the firm, such as ‘production’ or ‘marketing’. Each function, such as marketing or production, may further translate the overall strategy to a functional strategy. Third, strategy – as defined here – is *not* about planning out each and every detail, in at least 4 ways. First, as explained in Subsection 4.8, an optimal strategy for a project with 100 choices may consist of investigating just one single state and announcing one choice as the strategy, and then letting the participants choose based on their local information. In such case, barely anything is planned ahead. Second, even for a given strategy, the guided choices are not fixed as the participant still has a choice among  $N$  optimal alternatives. (The fact that these all have the same payoff could be relaxed.) Third, given a cost of investigation, not all choices will be guided. Fourth and most importantly, Subsection 4.7 will show that optimal strategies – as defined here – will often be dynamic once learning and experimentation are introduced. A fourth and final observation is that this definition implicitly assumes both a set of target outcomes towards which the strategy guides and an organizational context within which the strategy operates. With regard to the first, while a company can thus have a clear strategy that guides it towards a disastrous outcome, an ‘optimal strategy’ guides towards the constrained optimal outcome. With respect to the latter, a very important part of the organizational context is the ‘audience’, i.e., the people towards who the strategy is targeted, and what that audience knows, because that may determine what a strategy needs to specify. This will be partially formalized in Subsection 4.3 on uncertainty. Other important aspects of the organizational context include the identity of the strategist and the ability of the strategist to collect information. Some organizational choices will then precede strategy, some will be strategic, and some will be guided by the strategy. Strategy itself is essentially an organizational tool.

The introduction already related the definition to the literature. To do this in somewhat more detail, it is useful to relate the different elements of the definition to the existing management literature. The fact that the strategy is expressed in terms of a ‘set of choices’ is consistent with much of the management literature. Andrews (1971), for example, defines strategy as a ‘pattern of *decisions* [...]’; Porter (1996) describes it as ‘*choosing* [...] activities.’<sup>14</sup> The idea that the choices and decisions (that make up the strategy) ‘guide’ (towards an objective) is obviously implicit in the idea of ‘strategy as plan’ and is explicit in Mintzberg’s (1987) reference to ‘guidelines.’

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<sup>14</sup>Simon (1947) refers explicitly to game theory when defining strategy as ‘a series of such *decisions* which determine behavior’. Drucker (1973) defines strategic planning in part as ‘the continuous process of making (...) *decisions* (...)’. Barney (2011), despite defining strategy formally as a ‘theory’, informally describes it as a ‘*actions* [that] firms take’ (p10). Note that Barney’s (2011) ‘choice of theory’ can be interpreted in the context of Section 2 as the strategist announcing her beliefs about state variables, thus explaining the *logic* of the strategy. Doing so often makes sense, though giving *only* the logic – without the actual choices and decisions – might not be sufficient to get alignment.

It is also instructive to relate this paper’s definition to the practice-oriented list-based definitions of strategy by Andrews (1971), Bower et. al. (1995), Saloner et al. (2001) or Collis and Rukstad (2008). Collis and Rukstad (2008), for example, describe strategy – based on their experience – as specifying a choice of objective, a choice of scope, and a choice of advantage. This list of choices or decisions can be interpreted as an average experience-based ‘smallest set of choices to optimally guide the other choices’ for the most common situations. These thus give very concrete form to this paper’s definition. In the other direction, this paper provides a rationale and criterium for such a list and provides a logic for adjusting it to specific settings.

I now turn to the formalization of the definition in the context of the model of Section 2. What follows is more abstract and detailed than needed for the rest of the paper. The definition of strategy as the ‘smallest set of choices to optimally guide the other choices’ can be reformulated as follows: a strategy – given the set of target outcomes and given what the participants know and observe – is the smallest set of choices  $C_k$  to announce so that the equilibrium of the subgame starting in stage 2a implements one of the target outcomes. There is, however, an issue if we want to define ‘strategy’ for a potentially suboptimal outcome: the participants responsible for the strategic decisions may prefer not to implement them if the target outcome is suboptimal, even if the decisions would in fact guide to the target outcome. To sidestep this implementation issue, I will – for purposes of the definition of a general strategy (only) – condition on each decision  $C_k$  in the strategy being implemented when  $\theta_k = \tau_k$ , i.e., on all decisions announced in 1c automatically being fixed in 2b when the participant gets the strategist’s signal.

To now completely formalize this definition, I need to introduce some notations and terminology (that only matters in this section and will play no role in the further analysis). Let a target outcome, which may depend on the vector of signals  $\theta$ , be denoted  $\check{C}(\theta) = (\check{C}_1(\theta), \dots, \check{C}_K(\theta))$ . Let the set of target outcomes be denoted  $\check{\mathbf{C}}(\theta)$ . Let a ‘pattern of investigation’ be a complete contingent plan for the strategist with regard to which states to investigate in stage 1. (A ‘pattern of investigation’ is thus a game-theoretic-strategy for the strategist for stages 1a and 1b.) Let an ‘investigation outcome’  $\tilde{\tau}$  be the set of realized signals that the strategist has observed by the start of stage 1c. Let  $\theta_{\tilde{\tau}}, \theta_{-\tilde{\tau}} \in \theta$  be the subvectors of signals that the strategist has respectively investigated and not investigated by the start of stage 1c and  $\tilde{\theta}_{-\tilde{\tau}}$  a particular realization of  $\theta_{-\tilde{\tau}}$ . Note that – because the strategist’s choice of signals to investigate may depend on the realization of earlier investigated signals –  $\theta_{-\tilde{\tau}}$  may depend on that particular realization of signals  $\tilde{\tau}$  and not just on the investigation pattern. Denote the set of all possible realizations of  $\theta_{-\tilde{\tau}}$ , i.e., the set of all  $\tilde{\theta}_{-\tilde{\tau}}$ , as  $\Theta_{-\tilde{\tau}}$ . Let, finally,  $K_{\mathcal{S}} \subset K$  denote the indices of the subset of decisions that are part of the strategy  $\mathcal{S}$ .

**Definition 1** *A strategy  $\mathcal{S}$  (for a set of target outcomes  $\check{\mathbf{C}}(\theta)$ , for a commonly known pattern of investigation, and for an investigation outcome  $\tilde{\tau}$ ) is a set of choices  $(\check{c}_k)_{k \in K_{\mathcal{S}}}$  for a subset of decisions  $K_{\mathcal{S}} \subset K$  such that for some particular target outcome  $\check{C}(\theta) \in \check{\mathbf{C}}(\theta)$*

1.  $\check{c}_k = \check{C}_k(\tilde{\tau}, \theta_{-\tilde{\tau}})$  for all  $k \in K_{\mathcal{S}}$  and for all  $\theta_{-\tilde{\tau}} \in \Theta_{-\tilde{\tau}}$ ,
2. for any  $\tilde{\theta}_{-\tilde{\tau}} \in \Theta_{-\tilde{\tau}}$ , the outcome  $\check{C}(\tilde{\tau}, \tilde{\theta}_{-\tilde{\tau}})$  is an equilibrium outcome of the subgame starting in stage 2a for  $\theta_{\tilde{\tau}} = \tilde{\tau}$  and  $\theta_{-\tilde{\tau}} = \tilde{\theta}_{-\tilde{\tau}}$  when  $\check{c}_k$  was announced in stage 1c and fixed in stage 2b for all  $k \in K_{\mathcal{S}}$  and when the players update their beliefs given the pattern of investigation and the announcement in 1c,
3. there does not exist a set of decision choices  $\check{c}_k$  for a subset of decisions  $K_{\tilde{\mathcal{S}}} \subset K$  such that the two previous conditions are satisfied and  $\#K_{\tilde{\mathcal{S}}} < \#K_{\mathcal{S}}$ .

An optimal strategy formulation is a pattern of investigation and a set of strategies, one for each possible investigation outcome, that maximizes the overall payoff ( $R - c_I(I)$ ) and where the announced choices are also part of the subgame equilibrium.

An optimal strategy for  $\tilde{\tau}$  is a strategy for  $\tilde{\tau}$  that is part of an optimal strategy formulation.

A strategy does not necessarily exist for every pattern of investigation and  $\check{C}(\theta)$ , however. For example, if the pattern of investigation is empty and the desired outcome  $\check{C}$  is neither the trivial outcome nor a constant, then no strategy exists. But when the pattern of investigation investigates all signals, then a strategy exists for any  $\tilde{\tau}$  (that then includes a realization for each signal) and  $\check{C}$ : one candidate strategy that satisfies the first two conditions of the definition is  $C_k = \tilde{c}_k = \check{C}(\tilde{\tau}), \forall k$ , so that condition 3 then minimizes over a finite non-empty set and a strategy always exists. This further ensures that the overall problem of finding an optimal strategy is well behaved (as there is only a finite number of possible investigation patterns).

The following observation then captures the fact that the strategist will in equilibrium announce exactly an optimal strategy.

**Observation 1** *In equilibrium, the announcement in stage 1c is an optimal strategy.*

While this result follows directly from the setup, it is important because it explicitly and formally connects this paper’s definition of strategy with the process of ‘looking ahead to formulate an overall plan before making any particular decision’. This provides a clear rationale for the use of strategy in practice and a reference point to think about the concept.

## 4 The Nature of Strategic Decisions

I now turn to the main focus of this paper, the nature and value of strategy: what makes decisions strategic and what makes strategy important? These questions are of obvious importance: How do you find a strategy if you don’t know what you’re looking for? And why would you look for a strategy if you don’t know why it matters?

I will formally define a decision to be strategic to the degree that the decision was either investigated or announced as part of the strategy, where I will say that a decision was investigated if the information acquired by the strategist affects the (conditionally) optimal choice for that decision.

**Definition 2** *The degree to which a decision is ‘strategic’ equals the probability that it is, in equilibrium, investigated or announced as part of the optimal strategy.*

Let  $\pi_k$  denote the probability that  $C_k$  is investigated or announced as part of the equilibrium strategy. The probabilistic nature of the definition reflects the fact that the set of strategic decisions may depend on the state realization and also makes it possible to consider distributions over the parameter values.

Before discussing how specific characteristics make decisions strategic or strategy important, let me first discuss the equilibrium outcome of the game of Section 2, as that drives the results.

The equilibrium strategy announcement in step 1c creates effectively a hierarchy of decisions, with higher level decisions guiding lower level ones. Some of the strategic choices announced in 1c are the apexes (or roots) of the set of hierarchical trees. These decisions are chosen locally optimal ( $C_l = t_l^l$ ) and thus not guided by any other decisions. The other strategic choices announced in 1c align with one of these roots or with other strategic choices that are already part of such a tree. The non-strategic choices, finally, either align with one of the strategic choices (as the end-branch of such a tree) or do not align (and are then simply locally optimal but without guiding any other

decisions). Every strategic choice has at least one other choice aligning with it, and is thus either a root or an intermediate branch of a tree. Obviously, every strategic choice can have many other choices aligning with it. (In the extreme, there could be one strategic choice which all others choices align on.) Note, though, that while such a tree may in theory contain a very long path, in practice many ‘trees’ in a strategy are more like a brush: a root on which a set of non-strategic decisions align. The formal equilibrium is stated and derived in Lemma 2 of Appendix A (as it requires a lot of notation and definitions).

An important observation on this equilibrium (and thus on the model) is that, with probability one, no decision aligns with multiple choices at once. The most important example of (potentially) aligning with multiple decisions at once is when some decision, say  $C_n$ , aligns with  $C_k$  unless  $C_l$  and  $C_m$  both guide to the exact same choice, in which case  $C_n$  aligns with  $C_l$  and  $C_m$ . The reason why this doesn’t happen (with probability one) under the assumptions of Section 2 is that each choice has infinite alternatives, hence two choices guiding to the same alternative is a probability zero event. If there were a *finite* number of alternatives then this *does* happen, as in Van den Steen (2012c) which studies this explicitly and shows that the gain from strategy is larger in a supermodular case than in a non-supermodular case. But introducing that possibility in a model with many ( $K$ ) choices, with potentially many ( $I$ ) investigations, and with the possibility of reversion ( $\Delta_k > 0$ ), makes the model intractable and thus beyond the scope of this paper. While it is unclear what insights it would deliver beyond Van den Steen (2012c), it may be an important topic for further research. I now turn to the results themselves.

#### 4.1 Interactions, Level, Centrality, and Overlap

The first result is that having many and strong interactions makes a decision more strategic, especially when the decision’s interactions don’t overlap with those of other strategic decisions. The importance of this result derives from its practical implications:

- The fact that many and strong interactions make a decision more strategic implies, as illustrated in Figure 2, that both more central choices and higher-level choices are more strategic because they have more interactions. This suggests that when there is – for technological or organizational reasons – some exogenous hierarchy in decisions, then the strategic structure of the decisions will tend to mirror that exogenous hierarchical structure. In this sense, more important decisions will thus be more strategic.
- The role of overlap implies that effective strategies will often have one choice per function, such as a marketing choice, a production choice, etc.

This result – that many strong interactions make a choice more strategic – is intuitive (and not so surprising, once one works from the definition of this paper): decisions with many interactions can guide many decisions at once and, hence, should be more strategic. Overlap, on the other hand, leads to both duplication and conflict in guidance, making decisions less strategic.

The result also fits Merriam-Webster Online’s definition of ‘strategic’ as being ‘of importance within an integrated whole’, which indeed requires interaction as a necessary condition for being strategic. Whereas Merriam-Webster takes it as part of the definition, I derive it here endogenously as an implication of this paper’s definition.

Given the important implications, it is useful to start with a fairly black-and-white formal result.

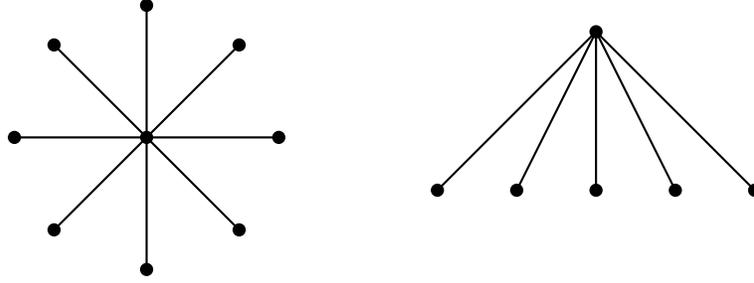


Figure 2: Interactions from centrality and from hierarchy

**Proposition 1** *A decision with no interactions is never strategic. Absent interactions, strategy has no value. (Formally: For any  $k \in K$ , if  $\gamma_{k,l} = 0, \forall l$ , then  $\pi_k = 0$ . If  $\gamma_{k,l} = 0, \forall k, l$ , then the optimal strategy is empty and strategy has no value.)*

A university department, for example, does not gain from a department-wide research strategy unless there are important interactions among the faculty members' research agendas, for example for hiring, joint projects, or external reputation. In the extreme, a firm with no interactions among its decisions (and with no specific investments and no strategic interactions with competitors) has no use for strategy, and may hurt its performance by trying to follow one.

While this extreme result puts the mechanism in perspective, a more general result is useful for practical purposes. The following proposition says that decisions are more strategic when they interact more – and more strongly – with other decisions, in particular for inbound interactions, and that strategy is more valuable when there are more and stronger interactions:

**Proposition 2** *A decision  $C_k$  is more strategic when the number and strength of its (inbound) interactions  $\gamma_{k,l}$  increase. The value of strategy increases in the number and strength of interactions  $\gamma_{k,l}, \forall k, l \in K$ . (Formally: The probability  $\pi_k$  (that  $C_k \in \mathcal{S}$ ) and the value of strategy both increase in  $\gamma_{k,l}$ , and in particular when going from  $\gamma_{k,l} = 0$  to  $\gamma_{k,l} > 0$  ('one more interaction') for  $T_{k,l} \in \Gamma_k$ . The value of strategy increases in  $\gamma_{k,l}, \forall k, l \in K$ .)*

One important example of interactions through *centrality* is the choice of scope, i.e., the choice of which customers to serve with which products. Andrews (1971), Bower et al. (1995), Saloner et al. (2001), and Collis and Rukstad (2008) all identified, as an experience-based rule-of-thumb, the choice of scope as an essential part of a business strategy. A small change in scope can reverberate throughout the whole business system.

An example of *higher-level* decisions being more strategic is that a decision to be 'low-cost' is more strategic than a decision to 'use CFL lamps in the store' because 'being low cost' has more implications for other decisions. But this result raises the question why the apparently *highest*-level choices, such as 'maximize shareholder value' or 'be the preferred service provider' are often *not* good strategic decisions. I will return to this below, in the section on uncertainty.

The formal result that a decision is more strategic when its interactions overlap less with those of other strategic decisions requires some of the formalism of Lemma 2. Let  $B = (\tilde{c}_l)_{l \in K_B}$  and  $B' = B \cup \{\tilde{c}_k\}$  be two candidate strategies in the sense of two IC sets of disjoint trees. The following proposition says that the added value of including  $C_k$  into the (candidate) strategy decreases with the overlap in interactions that  $C_k$  has with the other (candidate) strategic decisions.

**Proposition 3** *The added value from investigating and announcing  $B'$  instead of  $B$  decreases in  $\gamma_{m,l}$  for  $l \in K_B$  and  $m \in \cup_{n \in K_B} \Gamma_n \cap \Gamma_k$ .*

## 4.2 Persistence, Commitment, and Irreversibility

The second set of results is about the role of commitment, irreversibility, and persistence. These results are particularly important for a number of reasons. First, irreversibility and commitment are the only generic characteristic that the literature has explicitly identified as making a decision strategic, in particular in Ghemawat's (1991) seminal work, making them obvious characteristics of interest. It also means that comparing this paper's results to Ghemawat (1991) may give insight into both. Second, the analysis has some practical implications for optimal strategies. And, finally, these three characteristics have implications for the trade-off between commitment and flexibility, which is one of the most challenging issues in strategy.

In the analysis here, I will use the following definitions (in the context of 'strategy') to distinguish among irreversibility, persistence, and commitment:

- A decision is *irreversible* to the degree that it is hard to change or cannot be changed.
- A decision is *persistent* if it tends to remain unchanged over time. A decision's persistence can be due not only to irreversibility but also to the fact that there is no reason for changing it, for example, because the environment is very stable so that the optimal decision today is also the optimal decision tomorrow, or because the decision results from in-depth research or because it is founded on strong beliefs of the manager. I will refer to the choices that are persistent despite being reversible as 'stable' decisions. (The degree of stability is partially endogenous.)
- As a *commitment* is a pledge to do something, a choice is a commitment if it is an 'intentionally irreversible and visible choice', i.e., a choice that is *intended* to be irreversible and observable (to the right party). A commitment can be made in two ways: intentionally making an irreversible choice (e.g., a sunk cost) or intentionally making a choice irreversible (e.g., deciding to burn money rather than putting it into a safe). The latter type of commitments imply that the set of committed decisions is not a subset of the decisions that are inherently irreversible.

Whereas I thus define commitment in the sense of 'the act of committing' – with its forward-looking, voluntary, and visible nature – 'commitment' can also mean 'the state of being committed' and then has the nature of a constraint and is a source of 'irreversibility'. This distinction is critical because Ghemawat (1991) focused on the second meaning: he defines commitment as 'the difficulty to flip-flop,' argues that one can identify the commitment-intensive choices (in this sense) by looking for a specific set of adjustment costs (lock-in, lock-out, lags, and inertia) that make a choice difficult to reverse, but he does not mention intentionality or visibility (and hence the ability to influence others) as an essential part of commitment. Ghemawat then argued 1) that such irreversibility is the essence of strategy, 2) that it makes strategy valuable, and 3) that irreversible choices 'are the ones that should be treated as strategic.' I will discuss later how the results of this paper partially confirm and partially differ from these results.

The main results of this paper are as follows:

- Persistence makes a decision more strategic as it increases (ex-post) the value of aligning with the decision and hence also (ex-ante) the incentives to align with the decision, and thus its effectiveness guiding other decisions.

- The *possibility* of commitment may make a decision more strategic (when its natural persistence is insufficient). However, commitment will *not* always be used as it comes at a cost of potential ex-post misalignment. In fact, automatic commitment may make a decision *less* strategic. Persistence through stability makes a decision more strategic than persistence through commitment.
- Irreversibility does not necessarily make a decision more strategic and may even make it *less* strategic. It does, however, make strategy more valuable and also makes decisions with which it interacts more strategic.

The following proposition captures the first result, on *persistence*.

**Proposition 4** *A decision  $C_k$  is more strategic when it is more persistent, i.e., when  $\Delta_k$  decreases. The value of strategy increases in the persistence of the decisions.*

Persistent decisions – decisions that are unlikely to change – are more strategic for two reasons. First, a change in the decision will undo all the internal consistency that it was meant to generate. Hence, a more persistent decision will generate more internal consistency (ex-post). Second, anticipating this exact issue, other decisions will be less inclined to let themselves be guided by a non-persistent decision, making such decisions less effective as a guide.

This result has important implications for the *content* of strategy. First, it favors strategies that are built around more stable factors, such as strategies that focus on consumer needs that are unlikely to change. Second, in a volatile environment, strategy should be built more around internal factors, such as capabilities and resources, that are under the control of the organization and can thus be kept stable, rather than around products or needs that may change quickly. This is clear in high tech industries where firms often build their strategy around their capabilities and broad market needs, rather than around specific products or solutions. A third implication is that longer-term strategies and strategies in more volatile environments will be simpler because there are fewer persistent decisions. This effect will typically also make decisions about which the strategist is confident more strategic, as the strategist will expect less potential reversion (as  $\Delta_k < q_k$ ).

The result seems to suggest that *commitment* may be important to strategy as a commitment makes a choice persistent. The following proposition partially confirms that intuition, but also points out important caveats. To state the results, consider a variation on the main model of Section 2 in which the strategist  $S$  can publicly fix, at the end of stage 1, some of the choices announced in 1c at a cost of  $c_C$  per commitment. The choices that can be committed are a subset  $\mathcal{D}_c$  of all decisions.

**Proposition 5** *1) The option to commit makes a decision more strategic.*

*2) The strategist may not commit to a strategic decision even when it is possible. In fact, automatic commitment upon a strategy announcement may make a decision less strategic.*

*3) Persistence through stability makes a decision more strategic than persistence through commitment. Formally: if two decisions,  $C_k$  and  $C_l$ , are identical (incl.  $q_k = q_l$ ) except that  $\Delta_k = 0 < \Delta_l$ , but  $C_l \in \mathcal{D}_c$ , then decision  $C_k$  is more strategic than  $C_l$ .*

Let me start with the third result. The two decisions,  $C_k$  and  $C_l$ , have the same persistence *if* the strategist commits to  $C_l$ . Hence, the two decisions differ only in the source of their persistence: commitment ( $C_l$ ) versus stability ( $C_k$ ). And the result then says that persistence through stability makes a decision more strategic than persistence through commitment. The reason is that commitment comes at a cost: there may be an ex-post misalignment that could have been avoided absent commitment. Persistence through stability does not have that issue as there will be no reason to

change. It is for this same reason – losing the option to resolve ex-post misalignment – that the strategist may not use her ability to commit and that automatic commitment may make a choice *less* strategic: if ex-post local optimality is more important than the alignment that would come from commitment, then it is optimal not to commit, even if that means (in the case of automatic commitment) completely leaving the decision out of the strategy. Such automatic commitment may come, for example, from reputation concerns or from reactions by others.

Whereas a full analysis of *irreversibility* goes beyond the scope of this paper, a simple model can already give important insight in the effect of irreversibility and in Ghemawat’s arguments. In particular, I will consider a setting where all decisions are reversible and then investigate the effect of making one decision *irreversible*. Formally, consider a variation on the basic model with a third stage where all participants observe all choices and signals and then in random but pre-determined order publicly choose their (new) action. The following result then says that a decision does not become more strategic when it becomes irreversible but an increase in irreversibility makes strategy more important.

**Proposition 6a** *Irreversibility of  $C_k$  increases the value of strategy but does not make  $C_k$  more strategic.*

In fact, irreversibility can make a decision *less* strategic (in the presence of a public signal).<sup>15</sup> The first part of the proposition confirms Ghemawat’s (1991, p29-31) argument that irreversibility makes strategy more important: since you can’t align ex post, alignment has to come ex-ante through strategy. The second part, however, and especially the observation that irreversibility can make a decision less strategic, goes against his argument that irreversibility would make a decision more strategic. Ghemawat’s intuition was that irreversible decisions constrain other decisions and should therefore be chosen with great care. But the fact that an irreversible decision constrains other decisions does not imply that it *should guide* other decisions. The purpose of strategy is in part to let the *optimal* decisions guide rather than the *default* – i.e., irreversible – ones. This is best illustrated with an example from Ghemawat (1987). Around 1985, Coors needed to decide on the construction of a large brewery on the East Coast, which only made sense if Coors pursued a national (versus regional) strategy. Whereas the construction decision was the irreversible decision, the choice of geographic scope should be the strategic decision, guiding decisions such as the brewery construction. Letting the brewery construction – the irreversible decision – drive the choice of geography would put the cart before the horse. In conclusion, an irreversible decision makes it vital to develop a strategy but is not necessarily part of the strategy – at least not in the current setting – because irreversibility does not directly affect how useful the decision is as a guide for other decisions. We can in fact be more specific: irreversibility makes the decisions that can guide the irreversible decision more strategic.

**Proposition 6b** *Irreversibility of  $C_k$  makes decisions that interact strongly with  $C_k$  more strategic. (Formally: a choice  $C_m$  is more strategic when  $\gamma_{k,m}$  is larger.)*

This fits nicely with the Coors example: the irreversibility of the brewery decision made it important to guide that decision, which then made decisions that are effective guides for the brewery decision – in this case the choice of geographic scope – more strategic.

<sup>15</sup>For an example, consider a setting with 3 choices with  $Z_1 = \{C_2, C_3\}$ ,  $Z_2 = \{C_3\}$ , and  $c_I(I) = .1 + .2(I - 1)$ . All  $p_k = p_{k,l} = 1$ , while  $\alpha_1 = 0$ ,  $\gamma_{13} = 0.85$ ,  $\gamma_{12} = 1 = \alpha_2$ , and  $\gamma_{23} = 100 = \alpha_3$ . There is a signal about  $C_3$  that is correct with probability .9. Decision  $C_1$  is always irreversible. Consider the effect of making  $C_2$  irreversible. With  $C_2$  reversible,  $C_2$  is strategic, but not when it becomes irreversible: in that case  $C_3$  becomes strategic and with the guidance that already provides for  $C_1$ , the added value from also making  $C_2$  strategic becomes too small.

### 4.3 Uncertainty, Clarity, and Strategic Bets

Informally, it seems obvious that uncertainty plays an important role in strategy. But the exact effect of uncertainty on strategy is not so obvious. On the one hand, uncertainty makes it hard to develop a strategy, leading some to conclude that uncertainty makes strategy useless since tomorrow will look different (Martin 2013). On the other hand, uncertainty seems essential to strategy: without uncertainty, everyone knows what to do and where to go and there is no role for strategy. Uncertainty thus seems to make strategy both more and less valuable.

The analysis in this paper shows that the effect depends on the type of uncertainty: prior uncertainty (i.e., uncertainty that exists before investigating states) makes strategy more valuable and makes decisions more strategic while residual uncertainty (i.e., uncertainty that remains after investigating) makes strategy less valuable and makes decisions less strategic. A critical role of strategy is to reduce uncertainty *about what actions others will take*, which makes it hard to align.

To formally study the effect of *ex-ante uncertainty*, consider a variation on the basic model in which all players observe a public signal  $\tilde{\tau}'_k$  about decision  $C_k$ . The signal  $\tilde{\tau}'_k$  will be a garbling of the strategist's (potential) signal  $\tau_k$  that is correct with probability  $\rho_k < q_k$ . The signal thus reduces the ex-ante uncertainty about decision  $C_k$ . The question is how such reduction in uncertainty affects whether decision  $C_k$  is strategic and the value of strategy. The following proposition – which uses  $\Delta_{k'}$  for the probability that  $\tilde{\tau}'_k \neq \theta_k$  – then says that uncertainty makes a decision more strategic and increases the value of strategy:

**Proposition 7** *Decision  $C_k$  is more strategic and the value of strategy is higher when there is more uncertainty, i.e., when the signal  $\tilde{\tau}'_k$  is less informative ( $\Delta_{k'}$  increases). Moreover, uncertainty and interactions  $\eta_{k,l}$  are complements with respect to the value of strategy.*

The complementarity result gives some important intuition: the fact that uncertainty makes strategy valuable *only when* combined with a high level of interaction shows that ex-ante uncertainty matters *not* because it makes it hard to find the correct decision but because it makes it hard to predict what others will do and thus to align with them. The effect of strategy is indeed to reduce uncertainty about what others will do.

This result implies that high-level generic choices, such as ‘be the preferred service provider’ or ‘maximize shareholder value,’ are typically not strategic: as there is not much uncertainty about such choices, making them explicit as part of the strategy does not provide additional guidance to people’s decision making. In the other direction, this also explains why a choice *not* to do something – such as a choice *not* to be the preferred vendor in a particular segment – is often strategic, as such restrictions go against general expectations and are thus very informative.

The fact that *residual uncertainty* makes strategy less valuable and makes the decision less strategic was already captured in the results on persistence. But there is a further result, though that is easiest to see from the opposite direction: decisions with clear implications for other decisions are more strategic. As clarity of implications is captured by  $p_{k,l}$ , the formal result is:

**Proposition 8** *A decision  $C_k$  is more strategic, and the value of strategy increases, when the confidence  $p_{k,l}$  in its inbound interactions (with  $T_{k,l} \in \Gamma_k$ ) increases.*

Prior uncertainty makes strategy more important; residual uncertainty makes it less effective.

**Strategic Bets** When organizations face large uncertainty, it is sometimes said that it is more important for them to choose *some* direction than to delay in order to find the *optimal* direction.

This is related to the observation that managers of high-tech start-ups often talk in terms of ‘bets’ rather than strategy, reflecting a sense that they are forced to make important and far-reaching choices without having much information to base these choices on. Does it make sense to make such ‘bets’? In other words, what is the gain from *some* strategy, even when it may be uninformed and thus potentially suboptimal.

To analyze this formally, consider a variation on the basic model where the strategist cannot investigate any states at all but can still announce (and can now commit to) a strategy, i.e., can announce and fix decisions in stage 1c. What is the value from such a strategy ‘bet’ and what would such strategy look like? The following proposition shows that strategy can add value without information about the optimal decisions and even without knowing the interactions among them. Moreover, the best decisions to build a strategic bet on are decisions with limited local importance ( $\alpha_k$ ) or eventual confidence ( $p_k$ ) but strong and clear interactions.

**Proposition 9** *There is value from a strategy bet that contains  $C_k$  when the strength of inbound interactions  $\gamma_{k,l}$  (with  $T_{k,l} \in \Gamma_k$ ) and confidence in the interactions  $1 - p_{k,l}$  are large and when the importance of, and confidence in, local optimality are small. The value increases in  $\eta_{k,l}$  and decreases in  $\beta_k$ . The strength of interaction  $\gamma_{k,l}$  and confidence in the interaction  $1 - p_{k,l}$  are complements with respect to the value of a strategy bet.*

A first obvious question is how strategy can add value without the strategist even knowing how the decisions interact. The reason why strategy ‘works’ here is because people *want* to align their decisions with others when  $\eta_{k,l}$  is large, but they can only do so if they know what others will do. When  $\eta_{k,l}$  is sufficiently large relative to  $\beta_k$ , it becomes optimal to blindly commit one or more decisions, in order to allow others to align with these. But since the strategy is uninformed, the internal alignment comes at the cost of a loss of external alignment: under the optimal strategy bet, the external alignment is no better than random. The optimal strategy bet is therefore most valuable at high  $\eta_{k,l}$  but at low  $\beta_k$ .

This benchmark clarifies the role of strategy from a different angle: Without *any* strategy, the organization does relatively well on external alignment, but no better than random on internal alignment. With the optimal *strategy bet*, things switch to the other extreme: the organization does well on internal alignment, but no better than random on external alignment. The optimal *informed* strategy, finally, optimally trades off internal and external alignment.

An important challenge for ‘strategy as a bet’ is implementation: employees may doubt that managers will follow-through on the announced strategy. In fact, the optimal strategy bet is not an equilibrium if strategy is just cheap talk. A strategy bet thus requires a commitment device, which can be managerial reputation, a strategist-leader with strong views (Van den Steen 2012b), or an irreversible decision.

#### 4.4 Local Importance

‘Being strategic’ is often associated (or even equated) with ‘being important’. But in which direction does this relationship run? Does being strategic make a decision more important and, if so, why? Or are more important decisions more strategic? For strategy as defined here, the effect runs in both directions. In the one direction, strategic decisions are important because they influence or guide a lot of other decisions. In the other direction, Subsection 4.1 showed that important decisions, in the sense of hierarchically higher-level decisions, are more strategic.

There is also a second effect why important decisions would be more strategic, though it is more intricate: local importance ( $\alpha_k$ ) makes a decision more likely to be a root choice of strategy. To see

this formally, consider the case where the strategist investigates and announces only a single decision, i.e., she is restricted to the most core decision. Formally, let  $c_I(2) \rightarrow \infty$  so that investigating more than one state is never optimal. The following proposition says that more important decisions are more strategic.

**Proposition 10** *A decision  $C_k$  is more strategic when its local importance  $\alpha_k$  and eventual confidence increase.*

The same result obtains when the strategist can only investigate and announce root decisions in the sense that only  $T_k$  (and not  $T_{k,l}$ ) can be investigated.

There is also a *negative* result that *always* holds and that gives important intuition:

**Proposition 11** *No matter how locally important, a decision is not strategic unless it has sufficient interactions.*

While this follows from proposition 2, it matters here as it gives intuition: when locally more important decisions are more strategic, it is *not* because they have more impact on the project payoff, but because they will be made on their own terms, i.e., without regard to what is optimal for other decisions. The other decisions thus have to adapt to them and be guided by them if there is sufficient interaction. To make that possible, the important decisions must be a root choice of the strategy. A practical example of an important decision that is most often not strategic is an airline’s decision to hedge currency or fuel contracts: whereas such decisions have a tremendous impact on the bottom line, they usually do not guide other decisions – such as which customers to target – but are themselves guided by the cash flow needs implied by other decisions, and are therefore not strategic. Similarly, a technological choice buried deeply in a product design may critically affect a company’s success or failure, but that does not – by itself – make that decision strategic.

## 4.5 Specific Investments and Capabilities

A clear strategy not only facilitates alignment (or coordination) but also encourages investment in resources, skills, and capabilities, in particular when these resources and capabilities are specific to the firm’s course of action. The intuition is simple: with a clear strategy, employees know better which investments will pay off. For example, IKEA’s know how in low-cost flat-pack furniture design and Walmart’s know how in super-efficient logistics both seem to result, at least in part, from a persistent and clear strategy of cost minimization along specific dimensions. This intuition suggests that a choice will be more strategic, and strategy more important, when action-specific investments (in skills and capabilities) depend on it.

To derive this formally, consider a variation on the basic model in which – apart from the  $K$  participants  $P_k$  making decisions  $C_k$  – there are also  $L$  participants  $\tilde{P}_l$  that can each develop a capability  $K_l$ , such as know-how or a skill at performing a task. Each such capability  $K_l$  is related to a specific decision  $C_k$ . Moreover, each capability is choice-specific: when building a skill or capability  $K_l$ ,  $\tilde{P}_l$  has to specialize this skill towards some specific choice  $c_k^f \in C_k$  for that decision  $C_k$ . Capability  $K_l$  pays off only if  $C_k = c_k^f$ . Design skills, for example, only pay off if the firm pursues design-sensitive segments while cost-reduction skills only fully pay off if the firm pursues mass markets. (Almost all capabilities are to some degree choice-specific in the sense that the returns from the capability depend on the firm’s choices.) To develop the capability, participant  $\tilde{P}_l$  thus picks a specific choice alternative  $\tilde{c}_k \in C_k$  and then invests effort  $e_l \in \mathbb{R}^+$ , at a cost to the firm of  $e_l^2/2$ , which then generates an additional payoff  $\lambda_l e_l$  if and only if  $P_k$  chooses  $\tilde{c}_k$ . I will

assume that this investment is a separate task for which  $\tilde{P}_l$  is responsible, so that  $\tilde{P}_l$  maximizes  $\lambda_l e_l I_{C_k=\tilde{c}_k} - e_l^2/2$  while the objective of  $P_k$  remains unchanged. The  $\tilde{P}_l$  develop their know-how or capabilities in period 2a, simultaneous with the choice of decisions by the  $P_k$ . Let  $\mathcal{K}_k$  denote the set of all capabilities that are specific to the choice of  $C_k$ . The following proposition then says that choice-specific capabilities make a decision more strategic. Moreover, choice-specific capabilities and persistence are complements.

**Proposition 12** *A decision  $C_k$  is more strategic and the value of strategy increases when more, and more important, choice-specific capabilities depend on  $C_k$ . Moreover, choice-specific capabilities and persistence are complements in making a choice strategic. [Formally,  $\pi_k$  increases when for some  $K_l \in \mathcal{K}_k$ ,  $\lambda_l$  increases. Moreover,  $\lambda_l$  and  $1 - \Delta_k$  are complements w.r.t.  $\pi_k$ .]*

Another nice example of such choice-specific capabilities is Akamai (Van den Steen 2013). Due to the fact that Akamai’s technology is very different from its competitors’, Akamai’s employees have to make large investments in specific skills. As implied by the model, Akamai made its technology choice the core of its strategy and then committed to that strategy through an almost ‘religious belief’ by its leadership in the technology.

This result builds on Zemsky (1994) who showed that commitment to a strategy (interpreted as a choice of project) can create incentives for investments in choice-specific skills. This paper differs and contributes in two ways. First, the result here does not require commitment: a cheap-talk strategy is sufficient. Second, as Zemsky (1994) had only one choice and hence no way to investigate which choices are more or less strategic, that paper was about the effect of committing, while this result focuses on the structure of strategy.

## 4.6 Competition

Up to this point, the analysis focused on one firm where the strategist tried to maximize the firm’s payoff by announcing a strategy to guide internal decisions. But the paper’s model and logic can also be used to analyze competitive strategy, where the firm tries to influence competitors, complementers, and other external organizations. While the ‘guiding’ will then sometimes be more like ‘influencing’ or ‘forcing,’ the same logic applies. For example, a firm may expand capacity to force others to delay expansion. In that case, it tries to influence or guide others, and this paper’s definition of strategy as the ‘smallest set of (core) choices to optimally guide the other choices’ works. The purpose of this section is to derive some high-level results and, in the process, show more concretely how the model can work in a competitive strategy setting.

To study competitive strategy in a very simple context, consider a setting with a focal firm  $F$  with  $K$  choices, as before, and a second firm  $G$  that has one choice,  $C_g$ , with the two firms’ choices interacting and each firm having its own objective. The second firm can be any firm that interacts with the focal firm, such as a competitor, a complements, or a supplier. To fix ideas, I will interpret, and refer to, firm  $G$  as the ‘competitor’. Formally, let there be one (‘as if’) project with  $K + 1$  choices  $C_k$  that are partitioned into  $K + 1$  tasks  $Z_k$  of which one task – consisting of  $C_g$  and the interactions in  $Z_g$  – forms the competitor and the  $K$  other tasks form the focal firm. Interactions are simple, i.e.,  $\gamma_{k,l} = \tilde{\gamma}_{k,l}$ . The payoff of the competitor is exactly like before:  $\Pi_g = \alpha_g I_g + \sum_{T_{k,g} \in Z_g} \gamma_{kg} I_{k,g}$  where  $I_k = I_{C_k=T_k}$  and  $I_{k,l} = I_{(C_k,C_l) \in T_{k,l}}$ . The focal firm  $F$ ’s payoff, however, is now also affected by  $G$ ’s choices:  $F$ ’s profits have an additional firm-wide payoff term  $\tilde{\alpha}_g I_g + \sum_{T_{k,g} \in Z_g} \tilde{\gamma}_k I_{k,g}$ , where the competitive effects ( $\tilde{\gamma}_k$  and  $\tilde{\alpha}_g$ ), which capture the effects of  $G$ ’s choices on  $F$ ’s profits, can be either positive or negative. The participants  $P_k$  still care (only) about the payoff from their task

$Z_k$  and thus, in this simple case, don't consider these competitive effects. Each firm's strategist can (as a starting point) only investigate the states of its own choices. The firms make their strategy announcements sequentially in random order.

I want to consider two important questions within the context of this very simple model: what makes a decision strategic in such a competitive setting and what makes a competitor a 'strategic rival' in the sense that it has to be endogenized as part of the strategic analysis, i.e., in the sense that firm  $F$  has to consider  $G$ 's reaction when designing its strategy.

With respect to decisions being strategic, the following proposition says that decisions can be both more and less strategic when they can influence the competitor, depending on whether they influence in the right direction or not.

**Proposition 13** *A decision  $C_k$  is more (resp. less) strategic when it influences a competitor's or complements' choices in a sufficiently favorable (resp. unfavorable) direction to the focal firm. [Formally:  $\pi_k$  increases either if  $\tilde{\gamma}_k$  increases or if  $\gamma_{kg}$  increases at sufficiently high  $\tilde{\gamma}_k$ .]*

It follows that, in a one-shot static situation, capacities (strategic substitutes) are more strategic than prices (strategic complements). The result that competitive interactions can make a decision *less* strategic, however, depends on the competitor observing the firm's strategy. An interesting question for further research is what happens if the firm can make a cheap talk strategy announcement that is different for internal and external parties.

For the question on 'strategic rivals', I will formally define a firm  $G$  to be 'a strategic rival of a focal firm  $F$ ' if  $F$ 's optimal strategy depends on whether  $G$  has already made all its choices. Strategic rivals require extra attention when developing strategy since the focal firm will have to consider how strategic rivals will react to the firm's own choices. In other words, strategic rivals need to be endogenized when analyzing a competitive situation or developing a strategy, while other competitors can be taken as exogenous. For example, something like a demand curve for a set of firms is only well defined if and only if all strategic rivals are excluded when determining the demand curve. Similarly, strategic rivals have to be modeled explicitly when determining 'added value' in the sense of Brandenburger and Stuart. Hence, it would be useful to have a simple criterium to identify strategic rivals from the primitives of the setting. Consider, for example, the Nissan Leaf and Chevrolet Volt. Nissan's CEO had explicitly stated that he did not consider the Volt to be competition for the Leaf because of their different technological characteristics. The Volt, on the other hand, did react immediately to the Leaf's price changes in mid-2013, which suggests that they *did* consider the Leaf to be a competitor. What does this imply for the Volt and Leaf being potentially strategic rivals or not (from each firm's perspective)?

The following proposition establishes that a necessary and sufficient condition for being a strategic rival is the following two directional effect: the focal firm's choices must influence the competitor's actions – by affecting its payoff – and these competitor's actions must affect the focal firm's payoffs.

**Proposition 14** *Firm  $G$  is a strategic rival to  $F$  if and only if both  $\tilde{\gamma}_k$  (or  $\tilde{\alpha}_g$ ) and  $\gamma_{kg}$  are sufficiently different from 0.*

The answer is thus that neither the Volt nor the Leaf are a strategic rival to each other. From Nissan's perspective, the Volt is not a strategic rival because, according to Nissan's beliefs, the Volt's actions do not affect Nissan's profits. From the Volt's perspective, the Leaf is not a strategic rival because it does not react to Volt's actions. Given their beliefs, neither firm needs to consider the other when developing its strategy. This may seem surprising: as the Volt reacted to the Leaf's price change, shouldn't the Leaf consider that when developing its strategy? The answer

is negative *in as far as* Nissan maintains its original beliefs: as it does not consider the Volt to be a competitor, it does not matter to Nissan that the Volt’s price changed, so Nissan should not consider the potential Volt change when making its own choices.

## 4.7 Dynamics

The dynamics of strategy is one of its most challenging but also one of its most important aspects, as it drives the trade-offs between flexibility and persistence and between exploration and exploitation. Even though the basic model already considered some dynamics via the change in signals ( $\Delta_k$ ), it is for the most part static. A complete dynamic analysis would require learning and the possibility to change the strategy over time. While a full analysis is beyond the scope of this paper, this section presents a very simple example of a dynamic analysis in order to illustrate some basic points about the dynamics of strategy and to show how the model lends itself quite naturally to such analysis.

For the example, consider the model of section 2 with  $K = 3$  choices and with  $\gamma_{1,2} = 0$ ,  $\gamma_{1,3} = \gamma_{2,3} = \alpha_k = 1$ ,  $\Gamma_1 = \Gamma_2 = \{C_3\}$ , all  $\Delta_k = 0$ , and all  $p_k = p_{k,l} = .8$ . A concrete setting would be that  $C_1$  is a marketing choice,  $C_2$  is a production choice, and  $C_3$  is a product design choice. Product design can either be marketing-focused or production-focused. The timing repeats the basic model twice but with some interim feedback at the end of the first repetition, where everyone learns whether the payoff of  $\alpha_1 + \gamma_{1,3}I_{1,3} = 2$  or not, and all payoffs come at the end of period 4. In other words, everyone learns after the first repetition whether the marketing choice is a success but *only if* the company went ‘all the way’ on marketing.

The optimal dynamic strategy in this example is as follows: 1) In period 1, the strategist investigates and announces  $C_1$  as the strategy. In period 2,  $C_3$  aligns with  $C_1$ . 2) If the marketing approach turns out to be a success, i.e.,  $\alpha_1 + \gamma_{1,3}I_{1,3} = 2$ , then there is no more investigation or announcement and all players keep doing what they did before. 3) If, on the other hand, the marketing approach fails, then the strategist investigates and announces  $C_2$  in period 3 and  $C_3$  then aligns with  $C_2$  in period 4. However, if there was a need for an important strategy-specific investment in resources or capabilities or an important irreversible decision, then the optimal strategy may sometimes be to investigate and announce  $C_2$  and stick to that for the rest of the game.

This illustrates a few simple but important points. First, the optimal strategy is now dynamic: it changes over time depending on the events. Second, the strategy explicitly considers learning and such learning may make a choice both more strategic but also less strategic. Third, whether learning makes a choice more or less strategic depends on the importance of external alignment versus the need to make sunk investments, either as irreversible decisions or as action-specific investments in resources and capabilities. I conjecture that in a more complex setting, there would be persistence along some strategic dimensions and adaptation/flexibility along other dimensions, with learning and sunk investments being key drivers.

## 4.8 Strategy Process

The focus of this paper has been on the role of strategy as an *organizational tool* to give clear direction to an organization in order to improve alignment and specific investments. But strategy is also a useful *decision-making* tool to determine that direction. In particular, the paper (implicitly) shows how understanding the structure of strategy may enable a strategist to develop the optimal strategy in a very parsimonious way. First, the strategist needs to investigate and announce only the strategic decisions. Second, in many settings, the optimal number of strategic decisions is small so that the strategist needs to investigate and announce few decisions.

It is useful to make the latter point somewhat more explicit with an example. For the example, consider settings with  $K = 100$  and  $K = 1000$  choices with, for simplicity, all  $p_k = p_{k,l} = 1$ , all  $\alpha_k = 1$ , and all  $\gamma_{k,l} = 5$ . In a team-theory version of the model with no tasks, the optimal strategy will consist of exactly *one* choice for both  $K = 100$  and  $K = 1000$ . Moreover, that optimal strategy would give perfect guidance and achieve the first best. In the agency version of the model, the number of choices to investigate is random and depends on the cost of investigation and announcement. However, most often a strategy of 4 or 5 choices for  $K = 100$  and 6 or 7 for  $K = 1000$  can again achieve first-best if investigation were free. The strategies will be even more concise once a cost of investigation or announcement is considered but then, obviously, won't achieve the first-best any more. This example makes a few important points. First, a strategy can be very sparse relative to the set of decisions it is trying to guide. Second, this is particularly true in team-theory settings where employees care about the overall outcome. Third, and maybe somewhat surprisingly at first, a denser network of interactions seems to make strategy *more* effective, though more research is needed to confirm this.

There are two mechanisms outside the model that could further strengthen this parsimonious nature of strategy. First, Simon (1962) pointed out that systems in nature tend to have a hierarchical structure. Such hierarchical structure will tend to make strategy more effective. Second, employees typically know about more interactions than only their own. Such additional knowledge would also increase the effectiveness of strategy as a decision can be guided through a chain of links. Especially when combining the latter with the hierarchical structure, it is clear that strategy can be a very effective tool to guide organizations in real-world settings.

## 5 Conclusion

This paper developed a theory of (explicit) strategy – starting from a very simple but concrete formalization of strategy as ‘*the smallest set of (core) choices to optimally guide the other choices*’ – and used it to study which decisions are strategic and what makes strategy important, considering factors such as centrality, persistence, commitment, level, uncertainty, local importance, and more. In the process, it also showed that strategy – as defined here – can be a very effective organizational and decision tool, giving effective guidance with a limited number of investigations and announcements.

An important insight of the paper is how precisely the many things that we intuitively associate with strategy fit together: strategy as committing to one path, strategy as being decided by the CEO or general manager, strategy as coordination device, strategy as looking ahead, strategy as broad direction, etc. Such conceptual understanding of how these ideas hang together is helpful for thinking about and developing good strategies.

While the paper gives many insights, it also raises many questions. The study of dynamics and competitive strategy, for example, derived some important high-level insights and showed the use of this theory in these settings, but fell short of a complete and in-depth analysis. Especially the question of dynamics is an important one, as balancing flexibility and persistence and, closely related, dealing with high uncertainty and volatility are some of the most important challenges in practice. Beyond these, relaxing or modifying some of the assumptions could generate important insights. Examples are considering different payoff structures, endogenizing the precision of the signals, and allowing participants to learn more than just their immediate interactions.

This paper hopefully contributes to a broader study of the economic structure of strategy.

## A Proofs of Propositions

### A.1 Notation and Lemmas

The ordering  $\succ$  is defined as follows (with  $f$  and  $g$  strictly increasing functions):

- If  $X > Y$ , then  $X \succ Y$
- If  $f(\alpha_m) = g(\gamma_{k,l})$  then  $f(\alpha_m) \succ g(\gamma_{k,l})$
- If  $f(\gamma_{k,l}) = g(\gamma_{m,n})$  then  $f(\gamma_{k,l}) \succ g(\gamma_{m,n})$  iff  $k+l < m+n$  or, when  $k+l = m+n$ ,  $\min(k, l) < \min(m, n)$

and it is undefined otherwise.

Let  $\mathcal{I}$  be the set of states ( $T_k$  or  $T_{k,l}$ ) that is investigated,  $\mathcal{O}$  the set of observed signals,  $\mathcal{M}$  be the set of messages, and  $K_{\mathcal{M}} = \{k : m_k \in \mathcal{M}\}$ . Define  $a_k$  as follows:  $c_k^f \in a_k(c_l^g)$  if  $(c_k^f, c_l^g) \in T_{k,l}$ . Let an (alignment) path  $H_{kl}$  for  $k \neq l$  be a finite sequence drawn from  $\{C_1, \dots, C_K\}$  with all elements distinct, with  $i$ 'th element denoted  $H_{kl}^{(i)}$ , and with  $C_l$  as the first element and  $C_k$  as the last. Choice  $C_l$  is the root of the path. For some  $H_{kl}$  with  $i^*$  elements, let  $H_{kl}^T$  be a sequence of  $i^*$  elements with  $i$ 'th element denoted  $H_{kl}^{T(i)}$ , with  $H_{kl}^{T(1)} = C_l$  and element  $i > 1$  being the interaction state  $T_{m,n}$  for  $C_m = H_{kl}^{(i-1)}$  and  $C_n = H_{kl}^{(i)}$ . Define a revealed path  $h_{kl}$  that corresponds to  $H_{kl}$  recursively as follows: 1)  $h_{kl}^{(1)} = \tau_l$ ; 2) for  $i > 1$ , if  $H_{kl}^{(i)} = C_m$  then  $h_{kl}^{(i)} \in a_m(h_{kl}^{(i-1)})$ . Define, finally, for an  $H_{kl}$  with  $i^*$  elements:  $h_{kl}(\tau) = h_{kl}^{(i^*)}(\tau)$ . Define  $\underline{h}_{kl}$  as the set of all such  $h_{kl}$ . For the case where  $k = l$ , let  $H_{kk} = (C_k)$  and  $h_{kk}(\tau) = \tau_k$ . And completely analogous definitions with  $\theta$  instead of  $\tau$ . Let  $\mathcal{H}$  be the set of all (alignment) paths  $H_{kl}$ . Say that an alignment path  $H_{kl}$  is directed if, for  $i > 1$ ,  $H_{kl}^{T(i)} \in Z_m$  for  $C_m = H_{kl}^{(i)}$ , i.e.,  $H_{kl}^{T(i)}$  belongs to the task of the participant in charge of the  $i$ 'th element in  $H_{kl}$ . Say that a path is maximal with respect to a set of paths if there is no path with the same root of which it is a strict subset. Say that  $H_{kl}$  and  $H_{mn}$  are disjoint if they have no elements in common. A tree  $b_l$  is a set of maximal directed paths with common root  $C_l$  and such that if  $C_o = H_{kl}^{(i)}$  for  $H_{kl} \in b_l$  and  $C_o = H_{k'l}^{(i')}$  for  $H_{k'l} \in b_l$  then  $i' = i$  and  $\forall j < i$ ,  $H_{kl}^{(j)} = H_{k'l}^{(j)}$ .

Let  $B = \{b_1, \dots, b_v\}$  be a set of disjoint trees,  $B^c = \{C_m : \exists H_{kl} \in b_u \in B \text{ s.t. } C_m = H_{kl}^{(i)}\}$  the set of included decisions,  $B^r = \{C_l : \exists H_{kl} \in b_u \in B\} \subset B^c$  the set of roots of these trees,  $B^T = \{T_{m,o} : \exists H_{kl} \in b_u \in B \text{ s.t. } C_m = H_{kl}^{(i)} \text{ and } C_o = H_{kl}^{(i-1)}\}$  the branches of these trees.

Let  $\pi_m^B$  be the payoff associated with  $C_m$  according to  $B$ :

- if  $m \in B^r$ , then  $\pi_m^B = \beta_m$
- if  $m \in B^c \setminus B^r$  and  $C_m = H_{kl}^{(i)}$  for  $H_{kl} \in B$ , then  $\pi_m^B = \gamma_{m,o}(1 - \Delta_o)$  for  $C_o = H_{kl}^{(i-1)}$
- for the other choices  $C_m \notin B^c$ , we first need to define  $N_k$

Define then  $N_k$  as the choices that align with  $C_k \in B$  (under  $B$ ):

$$N_k = \{C_m : C_k \in Z_m^c \text{ and } \eta_{k,m}(1 - \Delta_k) \succ \beta_m \text{ and } \eta_{k,m}(1 - \Delta_k) \succ \max_{C_l \in B^c \cap Z_m^c} \eta_{l,m}(1 - \Delta_l)\}$$

Hence for  $C_m \in N_k$ ,  $\pi_m^B = \gamma_{m,k}(1 - \Delta_k)$  while for  $C_m \notin (B^c \cup_{k \in B^c} N_k)$ ,  $\pi_m^B = \beta_m$ . Say that  $B$  is incentive compatible iff for any  $H_{kl} \in B$  and for any  $C_m = H_{kl}^{(i)}$

- if  $i = 1$  (i.e.,  $C_m \in B^r$ ), then for any  $C_n \in B^c \cap Z_m^c \setminus C_m$ ,  $\beta_m \succ \eta_{m,n}(1 - \Delta_n)$
- if  $i \geq 2$  with  $C_n = H_{kl}^{(i-1)}$ , then  $\eta_{m,n}(1 - \Delta_n) \succ \beta_m$ ; for  $C_o \in B^c \cap Z_m^c$ ,  $\eta_{m,n}(1 - \Delta_n) \succ \eta_{m,o}(1 - \Delta_o)$

Define  $\Pi_B$  for such an IC set of disjoint trees  $B$ , as follows:

$$\Pi_B = \sum_{C_k \in B} \sum_{C_l \in N_k} \eta_{k,l}(1 - \Delta_k) + \sum_{C_k \in B^r \cup M} \beta_k$$

where  $B^r$  are the roots of the trees in  $B$ . Let  $\mathbf{\Pi}$  be the max over all IC sets of disjoint trees and  $\mathbf{B}$  the argmax set of trees.

**Lemma 1** For any  $H_{kl}, H_{km} \in \mathcal{H}$  (for  $H_{kl} \neq H_{km}$ ) the probability that  $\underline{h}_{kl} \cap \underline{h}_{km} = \emptyset$  is 1.

**Proof :** Consider first the case where each choice has  $M$  alternatives. For any  $H_{kl}, H_{km} \in \mathcal{H}$  (for  $l \neq m$ ) the probability that  $h_{kl} = h_{km} = 1/M$  which converges to zero as  $M \rightarrow \infty$ . ■

Let the event  $\text{ND} = \{(\theta, \tau) : \forall H_{kl}, H_{km} \in \mathcal{H}, H_{kl} \neq H_{km}, \underline{h}_{kl} \cap \underline{h}_{km} = \emptyset \text{ for both } \theta, \tau\}$ . Let  $\mathcal{H}(\mathcal{I})$  be the set of all (alignment) paths that can be constructed from  $\mathcal{I}$ , i.e., the subset of  $\mathcal{H}$  for which for each  $H_{kl}$ , the following holds:  $H_{kl}^T \subset \mathcal{I}$ . Let  $O_{\mathcal{I}}$  be the full set of (all possible) implied decisions:  $O_{\mathcal{I}} = \{h_{kl} : H_{kl} \in \mathcal{H}(\mathcal{I})\}$ . Let  $K_{Z_k} = \{l : T_{k,l} \in Z_k\}$  denote the set of indices with which  $P_k$  has an interaction in his task.

**Lemma 2** The (unique locally symmetric pure-strategy) equilibrium is:

- *Investigation:* For  $\mathbf{B}$ , investigate  $\mathbf{B}^r$  and  $\mathbf{B}^T$ .
- *Messages:* Announce a consistent set of implied choices  $m_k$ .
- For any  $C_k \in \mathbf{B}^r$ , choose  $C_k = t_k^k$ . For any other  $C_m$ , if  $C_m \in N_k$  for some  $k$  with  $m_k \in \mathcal{M}$ , then choose  $\delta_m^k$ , else choose  $t_m^m$ .

and its payoff equals

$$\Pi_{\mathbf{B}} = \sum_{C_k \in \mathbf{B}} \sum_{C_l \in N_k} \eta_{k,l}(1 - \Delta_k) + \sum_{C_k \in \mathbf{B}^r \cup \mathcal{M}} \beta_k$$

**Proof :** Throughout the proof, I will condition on the (probability 1) event ND unless otherwise noted. (As payoffs are bounded and  $D$  is a probability zero event, it will affect neither optimal actions prior to the state being revealed nor the expected payoff.)

Consider first the (iterative) investigation in steps 1a and 1b. In any locally symmetric pure strategy equilibrium (henceforth LSPSeq), LS implies that, conditional on ND, the set  $\mathcal{I}$  does not depend on the outcome of earlier investigations and is thus common knowledge.<sup>16</sup>

**Messages** Consider next the messages in stage 1c. First, in any pure strategy equilibrium (henceforth PSeq),  $\mathcal{M}$  can depend only on  $O$ .

Second, for any LSPSeq, there exists a set  $\tilde{\mathcal{H}} \subset \mathcal{H}(\mathcal{I})$  with at most one  $H_{kl}$  for each  $k \in K$  and one  $h_{kl}$  for each  $H_{kl}$  such that  $\mathcal{M} = \{h_{kl} : H_{kl} \in \tilde{\mathcal{H}}\}$  for any realization of signals. [To see this, fix first a  $\tau$ . Assume (by contradiction) that  $\exists m_k \in \mathcal{M}$  with no  $h_{kl} \in O_{\mathcal{I}}$  such that  $m_k = h_{kl}$  (for any  $\tau$ ). Pick some other  $c_k^x \notin O_{\mathcal{I}}$ . Relabeling  $C_k$  such that  $c_k^f = m_k$  and  $c_k^x$  are permuted, changes  $\mathcal{M}$  even though no element of  $O$  changed, contradicting the fact that  $\mathcal{M}$  can only depend on  $O$ . Assume next (by contradiction) that  $\exists \tau, \tau' \in \text{ND}$  such that  $h_{kl}(\tau) \in \mathcal{M}(\tau)$  but  $h_{kl}(\tau') \notin \mathcal{M}(\tau')$ . Relabeling states to switch every  $\tau_k \in \tau$  to  $\tau_k \in \tau'$  (but nothing more) should relabel all actions and choices in the equilibrium accordingly. But that implies that  $h_{kl}(\tau') \in \mathcal{M}(\tau')$ , which leads to a contradiction and thus proves that result.] This further implies that  $K_{\mathcal{M}}$  is fixed for any equilibrium. Let  $\mathcal{M}_R = \{m_k : m_k = \tau_k\}$  and  $\mathcal{M}_T = \mathcal{M} \setminus \mathcal{M}_R$ .

**Action restrictions from local symmetry** Consider now participant  $P_k$ . In any PSeq,  $P_k$ 's choice  $C_k$  must be a deterministic function of his information : his decision signal  $\theta_k$ , the potential strategist's signals  $\tau_k$  or  $\tau_{k,l}$  the local interaction signals  $\theta_{k,l}$  for  $l \in Z_k^c$ , and the messages in  $\mathcal{M}$  (which may include  $m_k$ ). LS further restricts this to  $\{\theta_k, a_k(\mathcal{M} | Z_k)\}$  and potentially  $\tau_k$ , where  $a_k(\mathcal{M} | Z_k) = \{a_k(m_l) : l \in K_{\mathcal{M}} \cap Z_k^c\}$ . Let  $\mathcal{T}_k$  denote the set of (potential) strategist signals for  $Z_k$ .

<sup>16</sup>This follows from local symmetry: permutating the signal would affect which states get investigated, while LS says that it shouldn't. That is not the case outside event ND. In particular, when implied choices may coincide, then the optimal choice of investigation will sometimes depend on observations, as analyzed in Van den Steen (2012c).

Second, in any equilibrium,  $P_k$ 's strategy is – potentially conditional on  $\tau_k = \theta_k$  or  $\tau_{k,l} = \theta_{k,l}$  – ‘always choose  $X$ ’ for some fixed  $X \in \{\theta_k\} \cup a_k(\mathcal{M} \mid Z_k) \cup \mathcal{T}_k$ . [To see this, I will first show that  $C_k \in \{\theta_k\} \cup a_k(\mathcal{M} \mid Z_k) \cup \mathcal{T}_k$  for any  $\theta$ . To that purpose, fix some equilibrium and some  $\theta$ . Assume (by contradiction) that  $\exists C_k$  with  $C_k = c_k^x \notin \{\theta_k\} \cup a_k(\mathcal{M} \mid Z_k) \cup \mathcal{T}_k$ . Pick some other  $c_k^y \notin \{\theta_k\} \cup a_k(\mathcal{M} \mid Z_k) \cup \mathcal{T}_k$ . Relabeling  $T_k$  to switch  $c_k^x$  and  $c_k^y$  (and nothing more) changes  $C_k$  even though no element of  $\{\theta_k\} \cup a_k(\mathcal{M} \mid Z_k) \cup \mathcal{T}_k$  changed, contradicting the fact that  $C_k$  can only depend on  $\{\theta_k\} \cup a_k(\mathcal{M} \mid Z_k) \cup \mathcal{T}_k$ . Pick next some  $\theta, \theta' \in \text{ND}$  and some  $C_k$ . Let  $C_k = X$  for some  $X \in \{\theta_k\} \cup a_k(\mathcal{M} \mid Z_k) \cup \mathcal{T}_k$  at  $\theta$ . Now permutate all signals from  $\theta$  to  $\theta'$ . Following LS, it remains true that  $C_k = X$  (even though the actual choice for  $C_k$  may change).]

**Beliefs** Consider now the beliefs (at the start of 2b) of some participant  $P_n$  about  $C_k$ . Let this belief, which is a distribution over  $\mathcal{C}_k$ , be denoted  $\mu_k^n$ . Note that, in any PSEQ,  $P_n$ 's beliefs can only depend on his decision signal  $\theta_n$ , his interaction signals  $\theta_{n,l}$  for  $l \in Z_n^c$ , the strategist's potential signals  $\mathcal{T}_n$ , and the messages in  $\mathcal{M}$ . LS further restricts that to  $m_k$  and, if  $k \in Z_n^c$ ,  $m_n$ ,  $\theta_n$ ,  $\theta_{k,n}$ , and  $\mathcal{T}_n$ .

The choice  $C_k$ , on the other hand, can only depend on  $\{\theta_k\} \cup a_k(\mathcal{M} \mid Z_k) \cup \mathcal{T}_k$ . The combination implies that in any LSPSEQ  $\mu_k^n$  can only depend on  $m_k$ .

The fact that  $\mu_k^n$  can depend at most on  $m_k \in \mathcal{M}$  implies that  $\mu_k^n$  (with, potentially,  $m_k \in \mathcal{M}$ ) are the same for all  $P_n$  and common knowledge. I will use  $\mu_k$  to denote these common knowledge beliefs. In the case that  $m_k \notin \mathcal{M}$ ,  $\mu_k$  is the ignorance belief: it puts equal weight on all possible alternatives for  $C_k$ . In the complementary case that  $C_k \in \mathcal{M}$ , the fact that  $\mu_k$  can only depend on  $m_k \in \mathcal{M}$  implies that  $\mu_k$  must put some probability  $\check{\mu}_k$  on  $C_k = m_k$  and put equal weight on all other alternatives for  $C_k$  (with overall the complementary probability  $1 - \check{\mu}_k$  but with the probability of any particular alternative equal to 0). The earlier arguments also implies that the value of  $\check{\mu}_k$  depends only on the equilibrium, not on any realization of signals or beliefs.

Let  $d_k$  denote the most likely choice for  $C_k$  according to  $\mu_k$  and let  $\psi_k$  denote the probability that  $C_k = d_k$ . The above implies that either  $d_k = m_k$  and is (thus) well-defined with  $\psi_k > 0$  or  $d_k$  is not well-defined (and  $\psi_k = 0$ ). Let  $\mathcal{D}$  be the set of  $C_k$  for which  $d_k$  is well-defined and non-trivial.

**Action choices** Consider now the action choice of some player  $P_k$  in stage 2b. Participant  $P_k$  solves

$$\max_{C_k} \beta_k I_{C_k=t_k^k} + \sum_{l \in K_{\mathcal{M}} \cap Z_k^c} \eta_{k,l} \psi_l I_{C_k=\delta_k^l}$$

where I used the fact that  $\psi_l = 0$  when  $l \notin K_{\mathcal{M}}$ . Since  $\beta_k > 0$  and all  $\eta_{k,l}, \psi_l \geq 0$ , the payoff increases in both  $I_{C_k=t_k^k}$  and  $I_{C_k=\delta_k^l}$ . Note, moreover, that ND implies that  $t_k^k$  and all  $\delta_k^l$  are distinct. It then follows that in a LSPSEQ,  $C_k$  either always chooses  $t_k^k$  or for some  $l \in K_{\mathcal{M}} \cap Z_k^c$  always chooses  $\delta_k^l$ . Let the set of participants (excluding  $P_l$ ) who choose  $\delta_k^l$  be denoted  $N_l$ . So the set of  $P_n$  is partitioned into one set  $M$  who choose  $t_n^n$  (and do not align with any decision) and a number of sets  $N_k$  who align with  $d_k \in \mathcal{D}$ .

The set of equilibrium actions is thus completely determined by the set  $\mathcal{D}$ . Moreover, we showed before that if  $d_k \in \mathcal{D}$  then it must be that  $d_k = m_k$  for some  $m_k \in \mathcal{M}$ , so that the set of actions is also completely determined by  $\mathcal{M}$ , in particular by  $\mathcal{M} \cap \mathcal{D}$ . Furthermore, in any equilibrium,  $\mathcal{M}^c \setminus \mathcal{D}_c = \emptyset$  since announcing some  $m_k$  with  $d_k \notin \mathcal{D}$  does not affect the outcome so that lexicographic preferences for less announcements imply that such announcements cannot be optimal in equilibrium. (So it follows that  $\mathcal{M} = \mathcal{D}$ )

Consider now some equilibrium and some  $C_k$  with  $m_k \in \mathcal{M}$ . If  $C_k = t_k^k$ , then it must be that  $m_k = \tau_k$  (since this is the only  $m_k = h_{kl}$  for some  $H_{kl} \in \mathcal{H}(\mathcal{I})$  for which  $d_k = m_k$ ). If  $C_k = \delta_k^l$  and thus aligns on  $d_l = m_l$ , then it must be that  $m_k = a_k^r(m_l)$  (since this is again the only  $m_k = h_{kl}$  for some  $H_{kl} \in \mathcal{H}(\mathcal{I})$  for which  $d_k = m_k$ ). But the fact that either  $m_k = \tau_k$  or  $m_k = a_k^r(m_l)$  (combined with the facts that there can be only one  $m_k$  for each  $C_k$  and that there can't be strong loops) directly implies that for every  $m_k \in \mathcal{M}$ , there exists exactly one directed  $H_{kl}$  such that  $m_k = h_{kl}$  and such that for each  $C_m \in H_{kl}$ ,  $m_m \in \mathcal{M}$  and  $m_m = h_{ml}$  for  $H_{ml} \subset H_{kl}$ . Combined with the fact that each choice  $C_k$  is optimal in equilibrium, this finally implies that the  $m_k$  form an IC set of disjoint trees  $B$ . Furthermore, since  $m_k = h_{kl}$  for some  $H_{kl} \in \mathcal{H}(\mathcal{I})$ , it follows that  $S$  then must have investigated at least  $B^r$  and  $T_B$ . Finally, as investigation is costly and no investigation beyond  $B^r$  and  $T_B$  affect the outcome,  $S$  will investigate exactly  $B^r$  and  $T_B$ . The payoff in this case is  $\Pi_B$ . Since  $S$  tries to maximize the payoff  $\Pi_B$ , it finally follows that the equilibrium is as follows:

- Investigation: For  $\mathbf{B}$ , investigate  $\mathbf{B}^r$  and  $\mathbf{B}^T$ .

- Messages: Announce a consistent set of implied choices  $m_k$ .
- For any  $C_k \in \mathbf{B}^r$ , choose  $C_k = t_k^k$ . For any other  $C_m$ , if  $C_m \in N_k$  for some  $k$  with  $m_k \in \mathcal{M}$ , then choose  $\delta_m^k$ , else choose  $t_m^m$ .

Before continuing, note now that in all equilibria the following holds: if  $m_k \notin \mathcal{M}$  then either  $P_k$  always chooses  $t_k^k$  or  $C_k \in N_m$  for some  $m \in Z_k^c$ , whereas if  $m_k \in \mathcal{M}$  then  $d_k = m_k$  with  $\psi_k = 1 - \Delta_k$ . It also follows from these arguments that if  $m_k = h_{kn}$ , the  $H_{kn}$  must a *directed* path.

- Investigation: For  $\mathbf{B}$ , investigate  $\mathbf{B}^r$  and  $\mathbf{B}^T$ .
- Messages: Announce a consistent set of implied choices  $m_k$ .
- For any  $C_k \in \mathbf{B}^r$ , choose  $C_k = t_k^k$ . For any other  $C_m$ , if  $C_m \in N_k$  for some  $k$  with  $m_k \in \mathcal{M}$ , then choose  $\delta_m^k$ , else choose  $t_m^m$ .

This completes the proof. ■

**Proof of Observation 1:** Consider Lemma 2. I need to show that the announcements in 1c are an optimal strategy.

Let me first show that the equilibrium announcement is a strategy for any investigation outcome. Following the lemma, the pattern of investigation is common knowledge and the set of  $S$ 's signals is the investigation outcome  $\tilde{\tau}$ . Take as target outcome simply the equilibrium outcome of Lemma 2 (which is defined for all possible investigation outcomes and states). Note that if  $S$  announces an action for  $C_k$  in period 1c (as part of the supposed strategy) then that action will in equilibrium indeed be chosen as long as  $\tau_k = \theta_k$ . This implies the first condition for a strategy. The second condition follows by construction from the definition of the target outcome. The third condition follows from the fact that in equilibrium every announced decision is also investigated and investigations are costly. Hence if a smaller announcement existed,  $S$  would have chosen it.

It also follows from Lemma 2 that the equilibrium investigations and announcement form an optimal strategy formulation. In particular,  $S$  chooses the pattern of investigation and – conditional on the investigation outcome – the announcements to maximize the overall payoff (including the cost of investigation). Furthermore, the announced choices are part of the subgame equilibrium as long as  $\tau_k = \theta_k$ . It follows that it is an optimal strategy formulation and the set of choices announced by the strategist in stage 1c is an optimal strategy. This completes the proof. ■

**Proof of Proposition 1:** Consider some decision  $C_k$ . Following Lemma 2, if  $\eta_{k,l} = 0 \forall l \in \Gamma_k$ , then  $N_k = \emptyset$ . It follows that  $\Pi_B$  does not depend on whether  $C_k$  is investigated or announced, so that  $S$  will prefer not to investigate or announce  $C_k$  (as that is costly). It follows that  $C_k$  will never be strategic.

The second part of the proof follows directly from the expression of  $\Pi_{\mathbf{B}}$ . ■

Let  $\tilde{\Pi}_B$  be the payoff from  $B$  including the cost of investigating  $B$ . Let  $\zeta_{kl} = \eta_{k,l}(1 - \Delta_k) = \gamma_{k,l}(2p_{k,l} - 1)(1 - \Delta_k)$ .

**Lemma 3** *A decision  $C_k$  becomes more strategic and the value of strategy increases when for some  $l$  with  $k \in K_{Z_l}$ ,  $\zeta_{kl}$  increases. Moreover, the value of strategy is supermodular in  $\eta_{k,l}$  and  $(1 - \Delta_k)$ . [Formally: The probability  $\pi_k$  that  $C_k \in \mathcal{S}$  increases in  $\zeta_{kl}$ . The value of strategy increases in  $\zeta_{kl}$ ,  $\forall k, l \in K$  and is supermodular in  $\eta_{k,l}$  and  $(1 - \Delta_k)$ .]*

**Proof :** Pick any set of parameters and any two decisions  $C_k$  and  $C_l$  with  $k \in Z_l^c$ . I will consider the effect of an increase in the value of  $\zeta_{kl}$  to  $\zeta'_{kl}$ , keeping all other parameters fixed. Let  $\mathbf{B}$  and  $\mathbf{B}'$  be the optimal IC sets of disjoint trees for, respectively,  $\zeta_{kl}$  and  $\zeta'_{kl}$ , and let  $\mathbf{\Pi}$  and  $\mathbf{\Pi}'$  be the respective payoffs.

Note that for any  $B$  with  $C_k \notin B$ , the payoff under  $B$  does not depend on  $\zeta_{kl}$  and whether  $B$  is IC or not also does not change with  $\zeta_{kl}$ .

I will first show that when  $C_k$  is strategic at  $\zeta_{kl}$ , it will remain strategic at  $\zeta'_{kl}$  and the payoff increases and is supermodular in  $\eta_{k,l}$  and  $(1 - \Delta_k)$ . So assume that  $C_k$  is strategic at  $\zeta_{kl}$ , i.e.,  $C_k \in \mathbf{B}$ . This implies that  $\mathbf{\Pi} \succ \Pi_B$  for any  $B$  that does not contain  $C_k$  and that is IC at  $\zeta_{kl}$ . That further implies – since IC does not change with  $\zeta_{kl}$  – that  $\mathbf{\Pi} \succ \Pi_B$  for any  $B$  that does not contain  $C_k$  and that is IC at  $\zeta'_{kl}$ . It thus suffices to show that either  $\mathbf{B}$  is IC at  $\zeta'_{kl}$  (and thus remains optimal) or that some other  $B$  that contains  $C_k$  is IC at  $\zeta'_{kl}$  and has a payoff strictly preferred over  $\mathbf{B}$ . To that purpose, I will now argue that if some set of disjoint trees  $B$  that contains  $C_k$  is IC at  $\zeta_{kl}$  but not at  $\zeta'_{kl}$ , then there exists a  $\tilde{B}$  that contains  $C_k$  that is IC at  $\zeta'_{kl}$  and that has a strictly preferred payoff. Consider thus any set of disjoint trees  $B$  that is IC at the original parameters and that contains  $C_k$ , i.e., such that there is some  $H_{no} \in B$  with  $C_k \in H_{no}$ . Let  $x$  denote the payoff from  $C_l$  under  $B$ , i.e.,  $x = \beta_l$  if  $l \in M$  and  $x = \zeta_{lr}$  if  $l \in N_r$ . Note first that  $B$  remains IC at  $\zeta'_{kl}$  if  $C_l \notin B$  or if  $C_l \in B$  and  $l \in N_k$ . So consider now  $C_l \in B$  but  $l \notin N_k$ . If  $\zeta'_{kl} < x$  then  $B$  is still IC at  $\zeta'_{kl}$ . If, on the other hand,  $\zeta'_{kl} > x$ , then consider  $\tilde{B}$  constructed from  $B$  as follows. Replace any  $H_{pq} \in B$  that contains  $C_l$ , i.e.,  $H_{pq} = (C_q, \dots, C_l, \dots, C_p)$  (and appropriately adapted when  $p = l$  and/or  $q = l$ ), with  $H_{po} = (C_o, \dots, C_k, C_l, \dots, C_p)$ . Notice that  $B$  and  $\tilde{B}$  contain exactly the same choices variables. Moreover, all choices are the same except for  $C_l$ .  $\tilde{B}$  is IC at  $\zeta'_{kl}$  (given  $\zeta'_{kl} > x$ ) and  $\Pi_{\tilde{B}} = \Pi_B + (\eta'_{k,l}(1 - \Delta_k) - x) \succ \Pi_B$ . This concludes the proof of the first part, i.e., that if  $C_k$  is strategic at  $\zeta_{kl}$ , then it will remain strategic at  $\zeta'_{kl}$ . To see that the value of strategy increases and is supermodular in  $\eta_{k,l}$  and  $(1 - \Delta_k)$ , it suffices to show that the optimal payoff increases and is supermodular in  $\eta_{k,l}$  and  $(1 - \Delta_k)$ . This follows immediately from above for the case that  $C_k$  is strategic at  $\zeta_{kl}$ . The argument for when  $C_k$  is not strategic at  $\zeta_{kl}$  is straightforward. In that case,  $\mathbf{B}$  does not contain  $C_k$  and neither its payoff nor whether it is IC depends on the value of  $\zeta'_{kl}$ . Since  $\mathbf{B}$  remains feasible at  $\zeta'_{kl}$ , the optimal payoff must be weakly higher. For supermodularity, the argument follows from the observation that the above implies that there exists a critical  $\zeta_{kl}$  below which the payoff is independent of  $\zeta_{kl}$  and above which the payoff contains the term  $\zeta_{kl}$  (and is thus supermodular in  $\eta_{k,l}$  and  $(1 - \Delta_k)$ ).

To see that the increases are sometimes strict, consider a setting with two choices,  $C_k$  and  $C_l$ , and let  $\zeta_{kl} = 0$  but  $\zeta'_{kl}(1 - \Delta_k) > \beta_l + c$ . This proves the proposition.  $\blacksquare$

**Proof of Proposition 2:** This follows directly from Lemma 3.  $\blacksquare$

**Proof of Proposition 3:** Let  $\check{C}_k$  be the optimal choice for  $C_k$  given  $B$ :  $\check{C}_k = t_k^k$  if for any  $C_n \in K_B$ ,  $\beta_k \succ \eta_{k,n}(1 - \Delta_n)$  while  $\check{C}_k = \delta_k^n$  for some  $n \in K_B$  if  $\eta_{k,n}(1 - \Delta_n) \succ \beta_k$  and for  $C_o \in B^c$ ,  $\eta_{k,n}(1 - \Delta_n) \succ \eta_{k,o}(1 - \Delta_o)$ . Let  $B'$  then be the IC set of disjoint trees generated by adding  $\check{C}_k$  to  $B$ . The value from investigating and announcing  $B$  equals

$$\Pi_B = \sum_{C_k \in B^c} \sum_{C_l \in N_k} \eta_{k,l}(1 - \Delta_k) + \sum_{C_k \in B^r \cup M} \beta_k$$

where  $N_k$  for  $B$  (for  $k \in K_{\mathcal{M}}$ ) is defined as  $N_k = \{C_m \in \Gamma_k : \eta_{k,m}(1 - \Delta_k) \succ \max(\beta_m, \max_{l \in K_B \cap Z_m^c} \eta_{l,m}(1 - \Delta_l))\}$ . Let  $V_{l|B}$  denote the value generated by decision  $C_l$  under  $B$ :  $V_{l|B} = \beta_l$  if  $C_l \in B^r \cup M$  and  $V_{l|B} = \eta_{m,l}(1 - \Delta_m)$  if  $C_l \in N_m$ .

To determine now the value from investigating and announcing  $B'$ , note that the payoff from  $C_k$  itself will not change as  $C_k = \check{C}_k$  both when  $B$  and when  $B'$  are investigated and announced. The difference is in the first term, which adds a term  $\sum_{C_l \in N'_k} \eta_{k,l}(1 - \Delta_k)$  with

$$N'_k = \{C_m \in \Gamma_k : \eta_{k,m}(1 - \Delta_k) \succ \max(\beta_m, \max_{l \in B'^c \cap Z_m^c} (\eta_{l,m}(1 - \Delta_l)))\}$$

and analogous for the  $N'_l$  in  $B'$  for  $l \in K_B$ . The added value from announcing  $B'$  instead of  $B$  can now be written as  $\sum_{m \in N'_k} [\eta_{k,m}(1 - \Delta_k) - V_{m|B}]$ . An increase in  $\gamma_{m,l}$  for  $m \in (\cup_{l \in K_B} \Gamma_l) \cap \Gamma_k$  and  $l \in K_B$  has two effects that both reduce the added value from announcing  $B'$  instead of  $B$ . First, it may reduce  $N'_k$  if  $(\eta_{l,m}(1 - \Delta_l) \succ \eta_{k,m}(1 - \Delta_k))$  due to the increase in  $\gamma_{m,l}$ . Second, it will increase  $V_{m|B}$  in

$\sum_{m \in N'_k} [\eta_{k,m}(1 - \Delta_k) - V_{m|B}]$  if  $m \in N_l$ . This proves the proposition. ■

**Proof of Proposition 4:** This follows from applying Lemma 3 for all interactions of  $C_k$ . ■

**Proof of Proposition 5:** Note first that the option to commit cannot make a decision less strategic: the option only matters if it is used and it can be used only if the decision is part of the strategy. For a set of parameters for which such commitment makes a choice more strategic, consider  $K = 2$ ,  $T_{12} \in Z_2$ ,  $p_1 = p_2 = p_{12} = 1$ ,  $\Delta_1 = 1$ ,  $\Delta_2 = 0$ ,  $\beta_1 = \beta_2 = .1$ ,  $\gamma_{12} = 1$ . Without commitment, no choice is strategic and  $\Pi = .2$ . With commitment an option for  $C_1$ ,  $C_1$  becomes strategic and the payoff increases to  $\Pi = 1$

For the second part of the proposition, consider the setting above but now with  $\beta_1 = 4$  and  $\Delta_1 = .5$ . The payoff without strategy equals  $\beta_1 + \beta_2 = 4.1$ . The optimal strategy absent commitment is  $\mathcal{M} = \{\tau_1\}$  with payoff  $\beta_1 + \gamma_{12}(1 - \Delta_1) = 4.5$ . If  $S$  were to commit to  $C_1 = \tau_1$ , the payoff would become  $\beta_1(1 - \Delta_1) + \gamma_{12} = 3$  and thus drops below the trivial payoff. It follows that  $S$  will not commit and  $C_1$  would cease to be strategic if commitment to the announced strategy would be automatic.

For the last part of the proposition, note the following. First,  $q_k = q_l$  and  $\Delta_k = 0$  imply  $p_k = q_k = q_l = (1 - \Delta_l)p_l$ . Next, pick a potential equilibrium with  $m_l \in \mathcal{M}$  but  $m_k \notin \mathcal{M}$  (and with equilibrium choices  $\hat{C}_k$  and  $\hat{C}_l$ ). I will argue that replacing  $m_l$  with  $m_k = \tilde{C}_k$  will weakly and sometimes strictly increase the payoff, which then completes the proof. Consider first the case that  $C_l$  were committed. Replacing  $m_l$  with  $m_k = \tilde{C}_k$  keeps all payoffs from  $C_m \neq C_l$  identical – as any choice that aligned on  $C_l$  will now align on  $C_k$  with the identical same payoff – while the payoff from  $C_l$  will weakly or strictly increase because  $C_l$  can now be chosen based on more informative signals. The payoff will thus improve weakly and sometimes strictly. Consider next the case that  $C_l$  were not committed but chosen optimally based on  $P_l$ 's local information. Replacing  $m$  with  $m_k = \tilde{C}_k$  keeps the payoff from  $C_l$  identical but will weakly or strictly improve the payoffs from  $C_m \neq C_l$  as it corresponds to an increase in persistence (from  $(1 - \Delta_l) < 1$  to  $(1 - \Delta_k) = 1$ ), so that the result follows from Proposition 4. This concludes the proof. ■

**Proof of Proposition 6a:** Let  $\hat{C}_k$  for  $k \in K$  denote the choices that maximize the project payoff for a given set of signals  $\theta$ . Let  $\hat{C}_{k|X}$  denote the choices that maximize  $\Pi$  (for a given set of signals) conditional on some event  $X$  (such as  $X$  being the event that  $C_l = c_l^g$ ). Let  $\hat{\Pi}$  and  $\hat{\Pi}_l$  denote the respective project payoffs

Notice first that with full reversibility, there is no value from strategy. In particular, it is straightforward that under ND (and no strong loops), this process of choice adjustments will lead to the  $\hat{C}_k$ . As investigations are costly but reversions are not, this process of adjustment is also cheaper than strategy and thus the optimal way to arrive at that.

Consider now the case that one choice  $C_k$  is irreversible. If  $\hat{C}_k = t_k^k$ , then there is no need for strategy as  $P_k$  will choose  $\hat{C}_k$  to start with. Consider then the case that  $\hat{C}_k \neq t_k^k$ . The outcome *without* strategy will then be  $\hat{C}_{l|C_k=t_k^k}$  with payoff  $\hat{\Pi}_{|C_k=t_k^k}$ . (With a strategy, however, the optimal outcome is not necessarily simply the unconditional optimum  $\hat{C}_l$  as that optimum may require a lot of investigations while one with a slightly lower payoff may require a lot less investigations.) To determine now the optimum for such cases *with* a strategy, let  $\mathcal{H}_{k-i}$  be the set of all directed paths with  $i \geq 1$  (distinct) elements that end in  $C_k$  such that for each  $H_{kl} \in \mathcal{H}_{k-i}$  and for each  $C_m \in H_{kl}$ ,  $C_m = \hat{C}_{m|C_k=h_{kl}}$ . (Note that  $\mathcal{H}_{k-1} = \{H_{kk}\}$ .) In other words, these are the directed paths such that if  $C_k$  is fixed according to that path, the path is indeed part of the optimal outcome.

For each  $i < K$ , let  $H_{k-i}$  be the element  $H_{kl}$  of  $\mathcal{H}_{k-i}$  that results in the highest overall payoff  $\hat{\Pi}_{|C_k=h_{kl}}$ . Let finally  $H_k$  be the  $H_{k-i}$  that maximizes the payoff subject to the cost of investigation, i.e., that maximizes  $\Pi(H_{k-i}) - c(i - 1)$ . The following is then the equilibrium: for  $H_{kl} = H_k$  investigate in stages 1a and 1b all but the last element of  $H_{kl}^T$ . If  $H_{kl}$  has  $i \geq 2$  elements and  $C_m = H_{kl}^{(i-1)}$ , announce  $m_m = h_{ml}$  for  $H_{ml} \subset H_{kl}$ . (If  $H_{kl}$  has one element, announce nothing. This is thus the outcome with no strategy.) In the subgame,  $P_k$  will choose  $a_k(m_l)$  (as he knows that that is, in equilibrium, his payoff-maximizing choice) while all others will choose, ultimately,  $\hat{C}_{m|C_k=a_k(m_l)}$ . (Note that all others will be able to adjust

after observing  $P_k$ 's choice.) It follows that the only strategic choice is (at most) a choice interacting with  $C_k$  and a choice  $C_m$  is more likely to be strategic when  $\eta_{k,m}$  is larger.  $C_k$  itself is never strategic, and the irreversible choice is in this case thus less strategic than the reversible ones. This proves the proposition. ■

**Proof of Proposition 6b:** This follows from the proof of Proposition 6a. ■

**Proof of Proposition 7:** Let  $C_k$  be the decision about which there is a public signal. A variation on the proof of Lemma 2 implies that the equilibrium takes one of the following two forms:

1. For some IC set of disjoint trees,  $B$ , with  $C_k \in B^c$ ,  $S$  makes the investigation and announcement as if there were no public signal. The actions are also as if there were no public signal. In other words, the signal gets overruled by an investigation.
2. For some set of disjoint trees,  $B'$ , with  $C_k \in B'$  and that is IC when replacing  $\Delta_k$  with  $\Delta_{k'}$ ,  $S$  makes the investigation and announcement as if no public signal exists with the following exceptions:  $S$  does not investigate  $Z_k$  but uses  $\tilde{\tau}'_k$  as its signal;  $S$  does not announce any  $m_k$ . In other words, the signal gets used as a message.

For the first case, the IC condition and the implied actions imply that conditional on  $m_k$ , the public signal is uninformative about  $C_k$  and the outcome is thus independent of the signal. In this case,  $\Pi_B$  will thus independent of the precision of the signal (as the IC conditions will never be affected by the presence of a signal that is a garbling of  $\tau_k$ ). It follows that the payoff of any potential equilibrium strategy with  $m_k \in \mathcal{M}$  is unaffected by the precision of the signal.

For the second case, Proposition 4 implies that the payoff increases in the precision of the public signal. Note that  $C_k$  is never strategic in an equilibrium of this second type.

It then follows that, as the precision of the signal increases, if the equilibrium is of type 1, then it will either not change (and the payoff remains the same) or change to an equilibrium of type 2 (with a higher payoff), making  $C_k$  non-strategic. If the equilibrium is of type 2, it will stay of type 2, keeping  $C_k$  non-strategic. This proves the first part of the proposition.

For the second part of the proposition, note that the payoff absent any strategy has increased since the public signal about  $C_k$  allows other choices to align with  $C_k$ . In particular, let  $\tilde{N}_k = \{C_l \in \Gamma_k : \eta_{k,l}(1 - \Delta_{k'}) \succ \beta_l\}$  for the subgame equilibrium without strategy, then  $\Pi = \sum_{C_l \in \tilde{N}_k} \eta_{k,l}(1 - \Delta_{k'}) + \sum_{C_l \notin \tilde{N}_k} \beta_l$  which thus decreases in  $\Delta_{k'}$  with derivative  $-\sum_{C_l \in \tilde{N}_k} \eta_{k,l} < 0$ . If the optimal strategy is of type 1, then the payoff is independent of  $(1 - \Delta_{k'})$  so that the gain from strategy indeed increases in  $\Delta_{k'}$ . If the optimal strategy is of type 2, then the payoff contains the term  $\sum_{C_l \in \tilde{N}_k} \eta_{k,l}(1 - \Delta_{k'})$  for  $\tilde{N}_k = \{C_m \in \Gamma_k : \eta_{k,m}(1 - \Delta_{k'}) \succ \max(\beta_m, \max_{l \in B^c}(\beta_m, \eta_{l,m}(1 - \Delta_l)))\} \subset \tilde{N}_k$ . The derivative then equals  $-\sum_{C_l \in \tilde{N}_k} \eta_{k,l}$  so that the derivative of the gain from strategy equals  $-\sum_{C_l \in \tilde{N}_k \setminus \tilde{N}_k} \eta_{k,l} \geq 0$ . This completes the proof. ■

**Proof of Proposition 8:** This follows directly from Lemma 3. ■

**Proof of Proposition 9:** Let the strategy bet be denoted  $\mathcal{S}$ . Following an argument that is completely analogous to the proof of Lemma 2, the payoff will be  $\sum_{C_k \in \mathcal{C}} \sum_{C_l \in N_k} \eta_{k,l}(1 - \Delta_k) + \sum_{C_k \in \mathcal{M}} \beta_k$  whereas the payoff without strategy bet is  $\sum_{C_k} \beta_k$ , so that the gain in payoff is  $\sum_{C_k \in \mathcal{C}} [-\beta_k + \sum_{C_l \in N_k} \eta_{k,l}(1 - \Delta_k)]$ . This immediately implies the proposition. ■

**Proof of Proposition 10:** If the strategy consists of investigating and announcing  $C_k$ , the expected payoff is

$$\Pi_{C_k} = \sum_{C_l \in N_k} \eta_{k,l}(1 - \Delta_k) + \beta_k + \sum_{C_n \in \mathcal{M}} \beta_n$$

hence the gain from a strategy over the trivial outcome is

$$\Delta\Pi_k = \sum_{C_l \in N_k} \eta_{k,l}(1 - \Delta_k) - \beta_l$$

As  $\beta_k$  increases, the gain a  $C_k$  strategy is unchanged while the gain from any other strategy weakly and for a non-empty part of the parameter space strictly decreases. This proves the proposition. ■

**Proof of Proposition 11:** This follows immediately from Proposition 2. ■

**Proof of Proposition 12:** With investments in specific capabilities, Lemma 2 and its proof change on only one point. Consider a capability  $K_l$  that depends on choice  $C_k$ . In stage 2a,  $\tilde{P}_l$  will choose to make the capability specific to  $d_k$  and then maximizes  $\psi_k \lambda_l e_l - e_l^2/2$  which gives  $e_l = \psi_k \lambda_l$ . It further follows that in any potential equilibrium, if  $m_k \in \mathcal{M}$  then  $e_l = (1 - \Delta_k) \lambda_l$  with payoff  $(1 - \Delta_k)^2 \lambda_l^2/2$ , else  $e_l = 0$ . The payoff from an IC set of disjoint trees  $B$  is then indeed  $\tilde{\Pi}_B$  and the equilibrium investigation and announcements will be  $\tilde{\mathbf{B}} = \operatorname{argmax}_B \tilde{\Pi}_B$ .

An IC set of disjoint trees  $B$  with  $C_k \notin B$  is independent of  $\lambda_l$  for  $K_l \in \mathcal{K}_k$ . For an IC set of disjoint trees  $B$  with  $C_k \in B$ , on the other hand,  $\frac{d\tilde{\Pi}_B}{d\lambda_l} = (1 - \Delta_k)^2 \lambda_l$  for  $K_l \in \mathcal{K}_k$ . Note that this is the same for *all*  $B$  with  $C_k \in B$ . It follows that if  $C_k$  is strategic, it will remain strategic when  $\lambda_l$  increases. When  $C_k$  is not strategic, it may become strategic. Finally,  $\frac{\partial^2 \tilde{\Pi}_B}{\partial \lambda_l \partial (1 - \Delta_k)} = 2(1 - \Delta_k) \lambda_l > 0$ . This completes the proof. ■

**Proof of Proposition 13:** Note first that the competitor  $G$  will not announce a strategy in this setting (as announcing a strategy can only affect  $F$ 's payoff and  $G$  thus prefers to make no announcement given the lexicographic preferences.) An argument completely analogous to the proof of Lemma 2 then implies that any potential equilibrium takes the following form:

- Investigation: For some IC set of disjoint trees  $B$ , investigate  $B^r$  and  $B_2$ .
- Messages: Announce a consistent set of implied choices  $m_k$ .
- For any  $m_k \in \mathcal{M}$ , choose  $C_k = m_k$ . For any other  $C_m$ , if  $C_m \in N_k$  for some  $k$  with  $m_k \in \mathcal{M}$ , then choose  $\delta_m^k$ , else choose  $t_m^m$ .
- Let  $\hat{k} = \operatorname{argmax}_{k \in K_{\mathcal{M}}} \eta_{k,g}(1 - \Delta_k)$ . If  $\eta_{\hat{k},g}(1 - \Delta_{\hat{k}}) < \beta_g$  then  $C_g = \theta_g$  else  $C_g = \delta_g^{\hat{k}}$ .

which gives  $F$  a payoff

$$\Pi_B = \sum_{C_k \in B} \sum_{C_l \in N_k} \eta_{k,l}(1 - \Delta_k) + \sum_{C_k \in \mathbf{B}^r \cup \mathbf{M}} \beta_k + \check{\alpha}_g I_{\eta_{\hat{k},g}(1 - \Delta_{\hat{k}}) < \beta_g} + \check{\eta}_{\hat{k}}(1 - \Delta_{\hat{k}}) I_{\eta_{\hat{k},g}(1 - \Delta_{\hat{k}}) > \beta_g}$$

and it gives  $G$  a payoff that is simply  $\beta_g I_{\eta_{\hat{k},g}(1 - \Delta_{\hat{k}}) < \beta_g} + \eta_{\hat{k},g}(1 - \Delta_{\hat{k}}) I_{\eta_{\hat{k},g}(1 - \Delta_{\hat{k}}) > \beta_g}$ .

It now suffices to show that in any equilibrium with  $C_k$  strategic,  $C_k$  remains strategic when  $\check{\gamma}_k > 0$  and either  $\check{\gamma}_k$  increases or  $\gamma_{kg}$  increases at sufficiently high  $\check{\gamma}_k$ . Note first that the payoff from any potential equilibrium with  $C_k$  non-strategic is independent of  $\check{\gamma}_k$  or  $\gamma_{kg}$ . So it suffices to show that the payoff from any potential equilibrium with  $C_k$  strategic increases in  $\check{\gamma}_k$  and increases in  $\gamma_{kg}$  for sufficiently large  $\check{\gamma}_k$ . Pick then any equilibrium with  $C_k$  strategic. (The proof for  $\check{\gamma}_k < 0$  is completely analogous.) Consider first the case that  $\hat{k} = k$  and  $\eta_{\hat{k},g}(1 - \Delta_{\hat{k}}) > \beta_g$  so that  $C_g = \delta_g^k$ . An increase in  $\check{\gamma}_k$  increases the payoff while an increase in  $\gamma_{kg}$  ensures that  $\hat{k} = k$  remains.

Consider next the case that either  $\hat{k} \neq k$  and/or  $\eta_{\hat{k},g}(1 - \Delta_{\hat{k}}) < \beta_g$  so that  $C_g \neq \delta_g^k$ . In that case, an increase in  $\check{\gamma}_k$  does not affect the payoff. An increase in  $\gamma_{kg}$ , on the other hand may make  $\hat{k} = k$  and  $\eta_{\hat{k},g}(1 - \Delta_{\hat{k}}) > \beta_g$  in which case  $C_g$  switches to  $C_g = \delta_g^k$ . This increases the payoff if and only if  $\check{\eta}_{\hat{k}}(1 - \Delta_{\hat{k}})$  exceeds the payoff that  $F$  received before, which will be the case if  $\check{\eta}_{\hat{k}}$  is sufficiently high. This proves the proposition. ■

**Proof of Proposition 14:** That follows from the proof of proposition 13. ■

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