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Entry and Deterrence in British Satellite Broadcasting

The first three case studies in this book focused on models of competition with fixed product characteristics and production technologies.¹ The next two featured, respectively, competition over new products and processes. This final detailed case study fixes on an even more fluid situation: competition to monopolize a new product market made possible by a process innovation in broadcasting technology.

To be more specific, the analysis in this chapter is motivated by a war of attrition between British Satellite Broadcasting (BSB) and Sky Television over the market for satellite TV in the United Kingdom. Like the two preceding cases, this one could be read as yet another instance of incumbent failure: BSB entered the market first, with an up-to-date broadcasting technology, was surprised by Sky's fast-second entry with an older but cheaper technology, and eventually collapsed into Sky's arms on less-than-equal terms. That is not, however, the principal point of this chapter. Rather, it is to probe, with the case as an anchor, two foundational questions about game theory: Can firms be treated,

1. This chapter is a substantially rewritten revision of Brandenburger and Ghemawat (1994). I am solely responsible for all changes.

as per usual practice, as unitary players out to maximize their own payoffs, and if so, should their interactions be expected to lead to Nash equilibria?

I begin by describing the BSB-Sky interaction and then work backward (as is customary in game theory) through these two questions in the context of product-market wars of attrition. The implications for game theory turn out not to be innocuous; for researchers in strategic management, there are also nontrivial implications concerning the content of effective competitor analysis.

7.1 Case Background

Satellite television involves the transmission of television signals from the ground to a satellite and back down to receivers. The satellite serves as a giant television tower, and the greater its power, the smaller is the size of the receivers required.

The World Administrative Radio Conference of 1977 reserved for each country several high-powered television broadcast channels that could be picked up by satellite dishes small and inexpensive enough to be installed at individual homes. In April 1986 the British government invited applications to provide a commercial service on the U.K. channels and received five serious bids. In December of that year, it awarded a fifteen-year franchise for high-powered direct broadcast by satellite (DBS) to British Satellite Broadcasting (BSB), a consortium of five companies formed to bid on the project.

By July 1987 BSB had completed a first round of equity financing that raised a total of £222.5 million from eleven companies. The bulk of this money was earmarked for buying and launching two high-powered satellites (one for redundancy). BSB estimated that it would install 400,000 satellite dishes by the end of

its first year of broadcasting (fall 1990), 2 million by 1992, 6 million by 1995, and 10 million by the year 2001. Operating break-even was expected at the 3 to 4 million mark in 1993, but the cost structure would continue to be dominated by mostly fixed (per-period) costs, such as program production and acquisition, marketing, and overhead. As a result the venture's economics would be very sensitive to the size of its customer base and its total start-up costs to its rate of market penetration. Total start-up costs were estimated at approximately £500 million and a second round of financing was scheduled for close to the commencement of broadcasting operations.

BSB's pursuit of these plans was disrupted in June 1988 by News Corporation's announcement that it would launch its own DBS venture in the United Kingdom, to be called Sky Television. News Corporation was a conglomerate, mostly in English-language media, that had recorded sales of about £3 billion and a return on sales of 7.8 percent in the preceding year. Its DBS service, Sky, was meant, like BSB, to be multichannel but was to be broadcast via a medium-powered satellite, Astra. Because of technological improvements, Astra could be received by acceptably small and inexpensive satellite dishes (although they would have to be somewhat larger than the dishes required to receive BSB's high-powered broadcasts).

The target launch date for Sky was in February 1989. News Corporation forecast that if this schedule could be met, Sky would install 1 million satellite dishes by the end of its first year of broadcasting and 5 to 6 million by the end of 1994. Operating breakeven was expected in late 1991 or early 1992 and total start-up costs, which would be shouldered by News Corporation, were estimated to be approximately £100 million. This estimate was substantially smaller than the corresponding figure for BSB because Sky did not need to launch its own satellites and

because it was counting on cheaper programming, lower overhead, and a quicker roll-out.

In response to Sky's entry announcement, BSB revised its sales projections to 5 million satellite dishes by 1993 and 10 million by 1998. It planned to accelerate sales by increasing advertising and promotion levels, mostly closer to its planned launch date. More immediate in its effects was the bidding war that broke out between BSB and Sky for exclusive British television rights to Hollywood films, which were seen as key to each service's economics because of their ability to generate significant subscription revenues. By the end of 1988, BSB and Sky had committed a total of about £670 million to Hollywood film rights, including up-front payments of about £150 million. Both figures appear to have been more than twice as large as anticipated.

Sky went on the air first, in February 1989, as planned. Dish sales proved disappointing, however: Sky's cumulative total at the end of its first year of broadcasting was less than 600,000 and was not increasing nearly as rapidly as had been projected. Reasons that were invoked included shortages of receiving equipment, Sky's patchy programming, negative advertising by BSB, rising interest rates, and atypically nice weather.

This period proved, in many respects, even more difficult for BSB. Higher-than-expected costs necessitated a supplementary first round of financing in January 1989 that raised £131 million and a second supplementary later that year involving £70 million. In May 1989, BSB announced that it would miss its fall launch date because of delays in developing a complicated new semiconductor chip required for its satellite dish receivers. Finally in February 1990, it concluded a second round of financing that ensured £450 million in debt from banks, conditional on the timely achievement of operating targets and a matching £450 million from shareholders. This money was meant to fund

"Operation Fastburn," which involved increasing marketing expenditures to levels unprecedented in Britain. By then, BSB's billion-pound-plus capitalization made it the second costliest start-up in British history, behind the Channel Tunnel.

BSB finally went on the air in April 1990, with the target of installing at least 3 million dishes in its first three years. BSB's cumulated sales between April and October 1990 came to 175,000 dishes. Sky out-installed BSB two to one over that period, adding more than 350,000 dishes and bringing its total to 950,000. But BSB beat it by roughly the same margin in the last three months of the period, installing 125,000 dishes to Sky's 58,000. At the end of October 1990, BSB was losing money at the weekly rate of £6 to £7 million and Sky at a rate of about £2 million. Sky's parent, News Corporation, was facing a cash crunch and renegotiating several billion dollars of debt with bankers, who were insisting, among other things, that something be done to staunch the cash outflows from Sky.

On November 2, 1990, BSB and Sky announced that they would merge into BSkyB, with control to be split fifty-fifty between BSB's shareholders and Sky's parent, News Corporation. As an apparent response to News Corporation's cash constraints, it was supposed to receive its "half" of the first £1.2 billion of positive operating cash flow from the merged entity somewhat earlier than BSB's financial successors. It would also shoulder less than half of any immediate cash transfusions that the merged entity might require. Another implication of the merger was emphasized by its official description as "a combination of Sky's commercial acumen with the financial resources of BSB's major shareholders." In practical terms, top managers from Sky Television/News Corporation took charge of the merged entity and fired most of its employees, most of whom had been inherited from the old BSB operation.

7.2 Theoretical Background

BSB and Sky collectively lost £1.25 billion in their war of attrition before they decided to merge; they then suffered several hundred million pounds of additional losses before reaching break-even. These are large numbers, especially in light of the much smaller start-up costs initially envisaged for both operations. Is such a bitter fight consistent with the use of Nash equilibrium strategies by players out to maximize their respective profits?

This broad question has been addressed the most explicitly in the context of labor strikes. By the end of the 1980s, a consensus seemed to be emerging that the observed length of strikes could not entirely be accounted for by received game-theoretic models of bargaining over a shrinking pie (e.g., Hart 1989). Since then, however, theorists have managed to figure out better ways of explaining the delayed resolution of strikes (e.g., Cramton 1992). These divergent conclusions are due to differences in informational conditions and, by implication, to uncertainty. Instead of probing strikes at greater length however, these informational issues will be pursued in the context of product-market wars of attrition, with the BSB-Sky case affording an anchor.

Received theory tells us that whatever the context, fighting in wars of attrition has to be fraught with uncertainty: that with perfect and complete information, the pure strategy equilibria in a duopolistic context, for example, involve immediate concession by one of the two players. Of course there are also mixed-strategy equilibria that involve fighting even when all else is certain, but they are subject to several problems. First, arbitrarily long fights occur with arbitrarily small probability. Second, each player is expected to be indifferent in every phase of the war between fighting and conceding because its expected payoff is invariant to that choice. Third, the idea of conscious randomization by

players (which is linked to payoff invariance) is hard to swallow in the context of long-run entry-or-exit decisions (as opposed to, say, short-run pricing decisions).

The simplest way of adding uncertainty (beyond that associated with the realizations of mixed strategies) to wars of attrition is to assume imperfect information about one or more structural parameters. It is easy, in such situations, to generate pure strategy equilibria that involve "fighting." Thus one might explain the war of attrition in U.K. satellite television in terms of imperfect information about the size of that market. In particular, one might stipulate that both BSB and Sky initially overestimated market size, leading them to expect to be profitable as duopolists and that they gradually came to their senses and decided to merge their interests.²

This is a conceptually coherent explanation of the war of attrition between BSB and Sky, and one whose attractiveness is increased by the fact that independent estimates of (medium- to long-run) market size fell over the period of that war. Still this explanation suffers from two significant limitations. First, the two competitors' dish-installation targets (and comparisons with the rate of penetration of the U.K. market by similar products such as VCRs) indicate that both ventures were initially aiming for a (near) monopoly. Second, even if this explanation did ring true, it would not "really" involve fighting: Both competitors would be willing to stay in as long as their (common) estimate of market size implied that they could operate profitably as duopolists, but as soon as the demand estimate drifted below that level (adjusted, perhaps, for option value), they would be back to the pure strategies of the perfect information world that involve immediate concession by one player.

2. Of course such an explanation fails, like the other discussed in this section, to explain why BSB and Sky did not merge at the very beginning of their interaction.

To "really" induce pure strategies that involve fighting, incomplete information is (as implied by the literature on the length of strikes) imperative. In its two-sided version, this would involve each of the two players being one of several possible "types," with each player knowing its own type but able only to guess at the other's. Each player's probability distribution over the other's type can be used to pin down a "Bayesian equilibrium" for a game of incomplete information of this sort (Harsanyi 1967, 1968a, 1968b). In the context of wars of attrition in growing (as opposed to declining) product markets, the leading example of such a model, cited in chapter 4, is Fudenberg and Tirole's (1986a).

In Fudenberg and Tirole's model, each player is uncertain about the other's level of fixed costs. The Bayesian equilibrium involves each player selecting a time, dependent on its beliefs about how its fixed costs stack up against its rival's, until which it will persist but after which it will withdraw if its rival remains active. With suitable boundary conditions, stopping times are greater than zero: It pays both players to lose money in order to be able to infer whose fixed costs are higher. And because information is revealed gradually, fighting goes on for a while.

This is, once again, a conceptually coherent explanation of the war of attrition between BSB and Sky but is subject, yet again, to a significant limitation. In Fudenberg and Tirole's (1986a) model, delayed selection requires ambiguity about relative cost levels. In the case being considered, however, there was public agreement that BSB's costs were significantly higher than Sky's because of its dedicated satellites, more expensive movie contracts, and sybaritic operating style. Selection should therefore have been relatively swift.

The line of analysis advocated by Harsanyi and implemented by Fudenberg and Tirole could perhaps be rescued, in the BSB-Sky context, by shifting the locus of incomplete information to some other structural parameter. But instead of doing so, Bran-

denburger and Ghemawat (1994) found it more plausible to shine the spotlight on strategic as opposed to structural uncertainty: on the idea that there might have been irreducible uncertainty about how "tough" one's rival could be expected to be. Such uncertainty, while assumed away by Harsanyi's (and Nash's 1951) formulation of equilibrium, seemed on the basis of both press accounts and interviews to have been a salient feature of the war of attrition between BSB and Sky. The question that is addressed in the next section is whether such uncertainty is adequate, given common belief in rationality, to account for lengthy wars of attrition in product markets.

7.3 Theoretical Analysis

To analyze the difference strategic uncertainty can make, consider a stripped-down version of the two-player war of attrition with zero structural uncertainty that unfolds in discrete time (indexed by $t = 0, 1, 2, \dots$). At the beginning of each period t , each player must choose between two actions: fighting and conceding. A player who, at the start of some period, chooses to fight incurs a cost of c that period, but a player who chooses to concede bears no costs. As long as at the start of each period both players continue to choose to fight, neither secures a monopoly. If, however, at the start of some period, one player chooses to fight while the other chooses to concede, then the first player secures a monopoly, which is worth V . If at the start of some period both players choose to concede, each player obtains the amount $V/2$. To ensure that the game is worth the candle, it is assumed that $V > 2c$. Players discount future costs and benefits at a common discount factor δ .³

3. These and the other assumptions of symmetry that follow are made in the interest of parsimony.

A player's choice of strategy in this war of attrition consists in choosing a stopping time, that is, a time at which to concede if the other player has not yet done so. Denote the two players as A and B , respectively. Then the set of possible strategies for player A can be written as $\{a_0, a_1, a_2, \dots, a_\infty\}$, where a_t , for $t = 0, 1, 2, \dots$, denotes the strategy of conceding at the start of period t (given that player B has not yet conceded), and a_∞ denotes the strategy of never conceding (always choosing to fight). The set of possible strategies for player B can be written in analogous fashion as $\{b_0, b_1, b_2, \dots, b_\infty\}$.

What are the possible outcomes to this game when players are rational (i.e., act to maximize their respective payoffs), each believes the other to be rational, each believes that the other believes that the first is rational, and so on ad infinitum? Answering this question requires a formal framework in which statements like "Player A ascribes probability 1 to player B 's ascribing probability 1 to player A 's being rational" can be written down and studied. Aumann and Brandenburger (1995, sec. 2) offer such a formalism, which they term an *interactive belief system*. This formalism enriches Harsanyi's treatment of types in a way that can be illustrated with exhibit 7.1, which presents a particular interactive belief system for the war of attrition.

In exhibit 7.1 a particular type of a player is associated with a probability distribution over the set of possible types of the other player, and (unlike Harsanyi's formulation) with a choice of strategy for the first player. Each row corresponds to a different type of player A and is labeled by the strategy that type chooses. Similarly each column corresponds to a different type of player B and is labeled by the strategy that type chooses.⁴ The probability

4. In general, this is not an adequate way of labeling types, since more than one type of a given player may choose the same strategy. (These types would then differ in the probability distributions held.) It suffices here because no two types of a player

Exhibit 7.1
An Interactive Belief System

	b_0	b_1	b_2	b_3	...	b_t	...	b_∞
a_0	0	$1-\varepsilon$	$1-\varepsilon$	$1-\varepsilon$...	$1-\varepsilon$...	$1-\varepsilon$
	0	0	0	0	...	0	...	1
a_1	0	0	$\varepsilon(1-\varepsilon)$	$\varepsilon(1-\varepsilon)$...	$\varepsilon(1-\varepsilon)$...	$\varepsilon(1-\varepsilon)$
	$1-\varepsilon$	0	0	0	...	0	...	ε
a_2	0	0	0	$\varepsilon^2(1-\varepsilon)$...	$\varepsilon^2(1-\varepsilon)$...	$\varepsilon^2(1-\varepsilon)$
	$1-\varepsilon$	$\varepsilon(1-\varepsilon)$	0	0	...	0	...	ε^2
a_3	0	0	0	0	...	$\varepsilon^3(1-\varepsilon)$...	$\varepsilon^3(1-\varepsilon)$
	$1-\varepsilon$	$\varepsilon(1-\varepsilon)$	$\varepsilon^2(1-\varepsilon)$	0	...	0	...	ε^3
.
.
a_t	0	0	0	0	...	0	...	$\varepsilon^t(1-\varepsilon)$
	$1-\varepsilon$	$\varepsilon(1-\varepsilon)$	$\varepsilon^2(1-\varepsilon)$	$\varepsilon^3(1-\varepsilon)$...	0	...	ε^t
.
.
a_∞	1	ε	ε^2	ε^3	...	ε^t	...	0
	$1-\varepsilon$	$\varepsilon(1-\varepsilon)$	$\varepsilon^2(1-\varepsilon)$	$\varepsilon^3(1-\varepsilon)$...	$\varepsilon^t(1-\varepsilon)$...	0

distribution associated with a particular type of player A is depicted by the lower-left entry in each cell of that row. Likewise the probability distribution associated with a particular type of player B is depicted by the upper-right entry in each cell of that column. In these distributions the parameter ε should be thought

make the same choice. Notice also that in the interactive belief system of exhibit 7.1, every strategy appears; that is, for each strategy, there is a type of player that chooses it. This need not be so in general.

of as some fixed number between 0 and 1. While different ε 's could be allowed in different cells, this representation is particularly simple and implies that the different types' distributions are "natural." The first type of either player (type a_0 or type b_0) thinks that the other player is a "fighter" and so throws in the towel immediately. The second type (a_1 or b_1) thinks that the other player may well concede immediately but, if the other player does not do so, gives up hope, concluding that the other player is a fighter and throwing in the towel. And so on. There is also a type of either player (a_∞ or b_∞) who is an "eternal optimist"—always of the view that the other player is going to concede and accordingly always choosing to fight.

To continue, a *state of the world* is simply a pair of types, one for each player. Specification of an interactive belief system for a game, together with the selection of a state in that system, constitutes a complete description of the strategies the players choose, the players' conjectures, their beliefs about other players' conjectures, and so on ad infinitum.

To see how this works, choose a specific state in exhibit 7.1, say (a_2, b_1) . This state describes a situation in which player A chooses the strategy a_2 and player B chooses the strategy b_1 . What is A's conjecture about B? It can be read immediately from the probability distribution held by A's type: Player A assigns a probability of $1 - \varepsilon$ to B's choosing the strategy b_0 , a probability of $\varepsilon(1 - \varepsilon)$ to B's choosing the strategy b_1 , and a probability of ε^2 to B's choosing the strategy b_∞ . Similarly player B assigns a probability of $1 - \varepsilon$ to A's choosing the strategy a_0 and a probability of ε to A's choosing the strategy a_∞ . What are A's beliefs about B's conjecture? These too can be read from the exhibit. Player A assigns (1) a probability of $1 - \varepsilon$ to B's type being b_0 , and hence to B's assigning a probability 1 to A's choosing a_∞ ; (2) a probability

of $\varepsilon(1 - \varepsilon)$ to B 's type being b_1 , and hence to B 's assigning a probability of $1 - \varepsilon$ to A 's choosing a_0 and a probability of ε to A 's choosing a_∞ ; and (3) a probability of ε^2 to B 's type being b_∞ and hence to B 's assigning a probability of $\varepsilon'(1 - \varepsilon)$ to A 's choosing a_t for $t = 0, 1, 2, \dots$. Player B 's beliefs about A 's conjecture can be read off in similar fashion. Indeed, it should be clear that all beliefs about beliefs about . . . one or another player's conjecture about its rival can be read from the exhibit in this way.⁵

What have been described so far are the players' choices, conjectures, beliefs about conjectures, and the like. But what about the players' rationality, their beliefs about each other's rationality, and so on? The interactive belief system describes that as well. Call a type of a player *rational* if that type's choice of strategy maximizes the player's expected payoff, calculated using that type's conjecture.

Type a_0 of A is clearly rational, since that type's conjecture ascribes a probability of 1 to B 's never conceding. What about type a_1 of player A ? Type a_1 assigns a probability of $1 - \varepsilon$ to B 's choosing b_0 (conceding immediately) and a probability of ε to B 's choosing b_∞ (never conceding). Given this conjecture, the operative choices for A come down to choosing between a_0 (conceding immediately) and a_1 (fighting once and then conceding). The expected payoff from choosing a_0 is $(1 - \varepsilon)V/2$, while the expected payoff from choosing a_1 is $-c + (1 - \varepsilon)V$. The strategy a_1 yields player A at least as high an expected payoff as a_0 provided that $-c + (1 - \varepsilon)V \geq (1 - \varepsilon)V/2$ or $\varepsilon \leq 1 - 2c/V$. In this case, type a_1 is indeed rational. A little thought shows that in fact every

5. In using the interactive belief system in this manner, there appears to be an implicit assumption that the system itself is in some sense "transparent" to the players. This is not in fact an assumption but a tautology. By design the interactive belief system already describes all the uncertainty facing the players.

type a_t of player A , for $t = 1, 2, \dots, \infty$, is rational exactly when the preceding inequality holds. And because of the symmetry of the interactive belief system in exhibit 7.1, the conditions for the various types of player B to be rational are the same as those just derived for the corresponding types of player A .

In what follows, it shall be assumed that $\varepsilon \leq 1 - 2c/V$. All types of either player are then rational, which can be illustrated by reconsidering the state (a_2, b_1) . It has already been established that at this state both players are rational. But what probability does A ascribe to B 's being rational? Type a_2 assigns a positive probability to B 's type being b_0 , b_1 , or b_∞ . Since each of these types of B is rational, A in fact assigns a probability of 1 to B 's being rational. Indeed, it is not difficult to see that since all types of either player are rational, there is common belief in rationality at (a_2, b_1) . That is, each player assigns a probability of 1 to the other's assigning a probability of 1 to . . . the rationality of one or another player.⁶ This observation leads directly to the first of two propositions developed in this section.

Proposition 7.1 Consider the discrete-time war of attrition. There is an interactive belief system for this game such that, given any number T , there is a state in the system at which:

- a. the players are rational,
- b. there is common belief in rationality,
- c. each player has a strictly positive expected payoff, and
- d. the players fight in each of the periods $0, 1, 2, \dots, T - 1$ and then concede in period T .

Proof Exhibit 7.1 itself is a suitable interactive belief system. Choose ε to satisfy $0 < \varepsilon < 1 - 2c/V$, and pick the state (a_T, b_T) .

6. In fact there is common belief in rationality at every state in the interactive belief system.

Given the choice of ε , all types of either player are rational; a fortiori, types a_T and b_T are rational, and there is common belief in rationality at (a_T, b_T) . The expected payoff of either of the types a_T and b_T is readily calculated to be $[-c + (1 - \varepsilon)V](1 - \varepsilon^T\delta^T)/(1 - \varepsilon\delta)$, which is strictly positive. \square

Proposition 7.1 implies that in the discrete-time war of attrition, a fight of any duration whatsoever is possible when the players are rational and there is common belief in rationality. That is, these two assumptions do not in any way restrict the possible outcomes of the game. Moreover both players can have strictly positive expected payoffs, even though they may both end up incurring overall losses.

Proposition 7.1 is not entirely satisfactory, however, because rationality and common belief in rationality obtain *ex ante* at the start of period 0: The players' expected payoffs are computed at the start of the game. The next question concerns what happens if rationality and common belief in rationality are required—in a sense to be made precise—to hold throughout the game, not just at the start. Analogously one might ask whether it is possible for the players to have strictly positive expected payoffs (calculated looking forward) throughout the course of the game.

Answering this second question requires incorporation of whatever the players learn as the game progresses into the interactive belief system. In fact that is readily done. Revert to some particular state of the interactive belief system in exhibit 7.1. Suppose that at this state the game lasts at least one period; that is, both players choose to fight in period 0. Consider now the situation at the start of period 1. Intuitively it is common belief at this point that player A did not adopt the strategy a_0 and player B did not adopt the strategy b_0 . The updated belief is captured formally by crossing out the first row and column of

the interactive belief system and renormalizing each type's truncated probability distribution.⁷ The situation at the start of period 1 is fully described by this updated interactive belief system, with the actual state being identified with that at the start of the game. If both players choose to fight in period 1 as well, the situation at the start of period 2 is described by crossing out the a_1 row and b_1 column of the updated interactive belief system and again renormalizing. And so on.

It is now possible to give formal content to statements like "player A is rational in period t ," or "player A assigns a probability of 1 in period t to player B 's being rational in period t ." Such statements are true if the corresponding condition holds at the given state in the t -times updated interactive belief system. And this leads directly to the second proposition of this section.

Proposition 7.2 *Consider the discrete-time war of attrition. There is an interactive belief system for this game such that, given any number T , there is a state in the system at which:*

- a. *the players are rational in each of the periods $0, 1, 2, \dots, T$,*
- b. *there is common belief in rationality in each of the periods $0, 1, 2, \dots, T$,*
- c. *each player has a strictly positive expected payoff (calculated looking forward) in each of the periods $0, 1, 2, \dots, T - 1$, and*
- d. *the players fight in each of the periods $0, 1, 2, \dots, T - 1$ and then concede in period T .*

Proof Exhibit 7.1 is once again a suitable interactive belief system. As in the proof of proposition 7.1, choose ε to satisfy $0 < \varepsilon < 1 - 2c/V$ and pick the state (a_T, b_T) . In this state the players are known to be rational, to have positive expected payoffs, and to

7. Alternatively expressed, the distribution associated with any given type of A is now a conditional distribution, calculated by conditioning on the event that B 's type is not b_0 . The updated distribution associated with any given type of B is likewise a conditional distribution, conditioned on the event that A 's type is not a_0 .

exhibit common belief in rationality at the start of period 0. Next observe that the updated interactive belief system, obtained by crossing out the first row and column in the exhibit and renormalizing, is isomorphic (up to the relabeling of types) to the original interactive belief system. It follows that at the identified state (a_T, b_T) , the players are rational, have strictly positive expected payoffs, and there is common belief in rationality at the start of period 1. The argument repeats. \square

To summarize the two propositions, there can be arbitrarily long fights in wars of attrition, even with common belief in rationality and without structural uncertainty. This conclusion, which is at odds with standard equilibrium reasoning, is due to strategic uncertainty and the "fog of war" that it can induce. Thus we have reached a negative answer to the second of the two foundational questions posed in the introduction to this chapter: Even if firms are treated as unitary players out to maximize their own payoffs, their interactions need not lead to Nash equilibrium.

7.4 Case Analysis

It is time to work back to the first of the two foundational questions about game theory raised at the beginning of this chapter: Can firms in fact be treated as unitary players who maximize their respective profits? This question is anathema to true-blue economists, who tend to treat (constrained) profit-maximization as axiomatic, but it is of intense interest to other researchers. The details of the BSB-Sky case provide some empirical perspective.

Available information, while far from complete, indicates that BSB was taken unawares by Sky's entry and reacted by digging in its heels. The first point will be dealt with summarily by citing BSB's treasurer, Richard Brooke: "We were not concerned about

competitive threats until Sky came along. Murdoch's announcement came from left field and took everybody by surprise." On the second point, it is instructive to look at how BSB altered its initial business plan in response to Sky's entry.

As noted above, BSB's initial business plan called for a customer base of 400,000 satellite dishes by fall 1990, 2 million by 1992, 6 million by 1995, and 10 million by 2001. Sky's entry prompted a revision of this plan, to a customer base of 5 million dishes by 1993 and 10 million by 1998. BSB now planned to accelerate penetration by increasing its marketing expenditures. This revised plan, like the initial one, was not communicated widely, suggesting that it was more than just "cheap talk" intended to influence potential customers' adoption decisions.

Upon closer examination the revision embodies an assumption that is curious at least in the context of the satellite case: that the transition from thinking that one has zero competitors to thinking that there is indeed one will lead to an increase in advertising expenditures large enough to lift optimal (own) volume with competition higher than optimal volume without it. One reason this assumption is curious is that the aggregate demand for satellite television in Britain was perceived to be relatively inelastic: a fixed pie, according to an industry observer. Another, more subtle but perhaps even more significant reason is due to the fact that the two competitors' technologies were incompatible, in the sense that their satellite dishes could not receive each other's programming. Potential British adopters of satellite television were reported to be concerned about being stranded with the wrong technology: Many of them had also been early adopters of VCRs (which had penetrated Britain relatively quickly) and quite a few had chosen Sony's Betamax standard—only to watch the VHS standard capture most of the market, limiting the availability of programming for their Betamax machines. Their concerns regarding satellite television were

intensified by significant hardware costs (£200 to £250 per dish) and by heavy advertising by BSB and Sky that, particularly on BSB's side, highlighted the issue of incompatibility. Thus competition may by inducing potential adopters to defer their adoption decisions until they could see which technology was winning out, have shrunk the size of the pie instead of merely failing to expand it much.

This line of reasoning is easily formalized in terms of a simple model related to Butters (1977) and Grossman and Shapiro (1984) that is explicit about how advertising affects customer behavior. Assume that advertising conveys information about the existence of a particular television service (a network of TV channels) and the consumer surplus it may afford to S potential adopters, each of whom will sign on with at most one of the two services. The potential adopters differ from each other only in terms of the advertising messages that they hear: The probability of reaching a particular potential adopter with a particular message is assumed to be r (where $0 < r < 1$) and to be independent of the probability that he/she will see another message sent by the same company, or for that matter by its rival. A potential adopter who receives no messages is unaware of the existence of the two television services and therefore purchases neither; a potential adopter who receives messages from just one of the two competitors is willing to pay up to u for that competitor's service; and a potential adopter who receives messages from both competitors responds by purchasing neither (or, if we were to be a bit more realistic, by deferring his adoption decision).

Firm i 's profit function can then be written:

$$\Pi_i = (u - c) \times S \times [1 - (1 - r)^{N_i}] \times (1 - r)^{N_j} - aN_i,$$

where the term in square brackets represents the probability that a representative potential adopter has seen at least one of firm i 's N_i advertisements, the term that follows it is the probability

that he/she hasn't seen any of rival firm j 's N_j advertisements, and c and a denote, respectively, variable production costs and the cost per advertising message. The first-order condition for interior maximization of profits by choosing the *optimal* advertising level, N_i^* , is

$$(1 - r)^{N_i^*} = -a/[(u - c) \times S \times \ln(1 - r) \times (1 - r)^{N_j^*}].$$

It is easy to check that the reaction functions slope downward: as N_j^* increases, N_i^* decreases. Therefore as firm i shifts from thinking that it has a monopoly (implying $N_i = 0$) to recognizing that it must compete against another firm which will advertise at positive levels (implying $N_j^* > 0$), that recognition decreases its optimal level of advertising, N_i^* , as well as its optimal penetration level (the optimized value of the product of two probabilistic terms in the profit function). The fact that BSB ratcheted up its plans for both advertising and penetration in response to Sky's entry is therefore doubly troubling.

Finally BSB's aggressive response is also troubling because Sky's entry announcement seemed to turn BSB into the underdog. BSB would launch several months (actually more than one year) later than Sky. BSB's dishes would be priced a bit higher, at £250 versus £200 (plus a £40 installation charge). BSB could count, at the time, on just three channels, compared to four for Sky, which might also benefit from television broadcasting on some of Astra's twelve other channels. Unlike News Corporation, BSB did not own a film library nor have experience with television broadcasting. BSB was also clearly the operation with the (much) higher overhead costs. And although BSB's transmission technology would enhance the sight and sound performance of new television sets equipped to take advantage of it, there were indications that the incremental benefits would not be enough to justify the added costs (and risks). Perhaps the most telling sign

was the withdrawal from the BSB consortium of Amstrad, a marketer and distributor of consumer electronics, that was supposed to ensure availability of the satellite dishes and other hardware. Amstrad's founder and top manager, Alan Sugar, appeared alongside his counterpart at News Corporation, Rupert Murdoch, when the latter announced the launch of Sky and, in his new role as Sky's principal supplier of dishes, dismissed BSB's technology as "a lot of nonsense which requires a lot of redundant components."

For all these reasons, BSB's response to Sky's entry—ratcheting up its planned advertising and penetration levels—is hard to rationalize with profit maximization. According to industry observers, it more plausibly reflects a chief executive officer, Anthony Simmonds-Gooding, who was personally committed to making BSB an unqualified success in order to cap off a distinguished career in marketing, as well as a governance structure, consisting of an unwieldy consortium of BSB's shareholders, which was unable to rein him in until much later on.

Devout profit-maximizers may not be convinced by this interpretation. Indeed, they may even be able to seize upon features of the British satellite broadcasting industry (e.g., network externalities) to concoct stories that make attempts to accelerate penetration the optimal response to the emergence of competition. Although it is difficult to anticipate, let alone address, all the stories that might be devised to protect the postulate of profit maximization in this particular case, more general questions can be raised about the efficacy of such immunizing stratagems. A large body of empirical evidence indicates that individuals and firms often irrationally escalate commitment to losing courses of action in competitive situations because of the sunk cost fallacy, attempts to justify past choices, selective perception, autistic hostility, and various other biases and distortions.⁸ A pure faith

in the prevalence of profit maximization throughout wars of attrition would appear therefore to be misplaced.

7.5 Reflections

In addition to the perspective that it provides on the foundations of game theory, the BSB-Sky case also sheds light on an important topic in strategic management: competitor analysis. Begin with what game theory itself suggests in this regard: using the interplay of competitors' incentives and, in particular, the concept of strategic equilibrium, to pin down the outcomes of competitors' interactions. While this approach is subject to its own limitations, as noted in the last two sections of this chapter, explicitly strategic (self-consciously interactive) analysis along the indicated lines *can* be fruitful if the cases discussed earlier in this book, particularly in chapters 2 through 4, are any guide. Such interactive analysis is nonetheless absent from received frameworks for competitor analysis in strategic management (e.g., Porter 1980, ch. 3).

More recent contributions to strategic management can be read as identifying some of the ways in which the "no-fat" models preferred by game-theorists need to be enriched to illuminate interactions among actual firms. Thus the resource-based view (RBV) of the firm (Wernerfelt 1984) suggests that firms' resource precommitments should be expected to have a major influence on their behavior. A recent extension by Teece and Pisano (1994) focuses on the variability of firms' resource endowments in the operational long run (the RBV focuses on the operational short run), and suggests that differences in "dynamic capabilities" (the

8. Consult, for instance, Bazerman and Neale (1992, ch. 2) and Rubin, Pruitt, and Kim (1994, ch. 7).

efficiency with which new product market opportunities can be exploited or resource endowments upgraded) drive the course of competitor interactions. Based on past form, we may yet be subject to an even more dynamic story in which the flexibility to shift capability thrusts is asserted to be the key strategic advantage. And so on.

These dissimilarities mask an important similarity in recent thinking in strategic management: the idea that at any given point in time, competitors' opportunity sets can be taken to differ because of resource/capability/flexibility constraints. Recognition of such differences in opportunity sets significantly enriches "no-fat" competitor analysis. But it is still not rich enough because it ignores a key principle of evolutionary economics: that performance relative to competitors depends not just on opportunity sets but also on the strategies that are actually tried. To make the same point in other words, resource/capability/flexibility constraints can, in principle, be reconciled with conventional microeconomic analysis, which presumes profit maximization, by postulating constrained profit maximization instead.⁹ Nonoptimal choices from opportunity sets, in contrast, cannot be assimilated in this fashion but can still have a major influence on the course of interactions. For instance, would it have been rational for Sky to enter, in spite of all its competitive advantages, if it had anticipated that BSB's response would be to increase rather than decrease its commitment, through an incompatible technology, to a market that appeared likely to prove a natural monopoly? To ask this question is to wonder whether deviations from profit maximization contami-

9. Tirole (1988, pp. 50-51) has articulated the hope that even when competitors do not manage to maximize their respective profits, their organizational inefficiencies might be separable (in terms of third-party observation) from their product market interactions.

nated the whole play of the game, in the sense of being responsible for the fact that there was any fight at all.

By implication, if competitor analysis is to be useful in the real world, it should supplement the economic analysis of incentives, capabilities and precommitments with behavioral analysis of predispositions. Numerous factors that shed light on such predispositions, as well as influences on their strength, have been identified in the literature on strategic management. Thus strategies are likely to persist, particularly if past performance has been satisfactory. The personal motivations of managers are likely to matter as well, particularly if governance-related restraints or incentives are weak. And so on.

To make the requirements for and rewards to expanded competitor analysis concrete, reconsider News Corporation from BSB's perspective. BSB was, as noted above, apparently blindsided by News Corporation's entry. It might have been more likely to identify News Corporation as a potential competitor ahead of time had it used an expanded framework for competitor analysis that looked at resources, capabilities, strategies, and personalities as well as the sorts of interactive considerations highlighted by the "no-fat" theoretical model analyzed earlier.

Preexisting resources that made News Corporation a particularly threatening potential entrant included not just the fact that it was already the second-largest media conglomerate in the world but, more specifically, its ownership of the film library and production capabilities of Twentieth Century-Fox, a major Hollywood studio, and of newspapers that accounted for one-third of British daily circulation (which could be—and were—used to promote Sky), as well as the political goodwill of British Prime Minister Margaret Thatcher and her Conservative party (which was important because of gray areas in the regulation of satellite TV).

Capabilities are a fuzzier category, but one can cite News Corporation's previous experience with satellite television, particularly the pan-European Sky Channel, and perhaps also its history of skirting regulatory loopholes and beating competitors to the air, which can be traced back to its entry into television in Australia. In the late 1950s, when the Australian government allotted News Corporation one of two commercial television broadcasting licenses for Adelaide rather than the monopoly its founder, Rupert Murdoch, had campaigned for, News Corporation successfully raced to be the first to begin broadcasting. And in 1962, when News Corporation was denied a stake in the new license for Sydney, it threatened to broadcast to the city anyway by buying an unprofitable station in a town sixty miles away as well as access to some U.S. television programming. The competitor that had won the Sydney franchise conceded a 25 percent stake to News Corporation.

Numerous aspects of News Corporation's revealed strategy—patterns in its past choices—further amplified the threat of its entry. At a corporate level, News Corporation was shifting its emphasis from print to electronic media and, within the latter category, was focusing on satellite, as opposed to cable, transmission. It was also focusing on English-speaking markets, and while it owned significant newspaper and television interests in Australia and the United States (where its Fox Broadcasting Company appeared to be succeeding as the fourth television network), its interests in the second-largest English-speaking market, Britain, were confined to newspapers. News Corporation had indicated its general interest in British television by purchasing a 7.5 percent stake in the ailing Independent Television (ITV) franchise for London in the mid-1970s (which it divested a few years later, reportedly because it felt that it did not have enough influence on the station's positioning). A recent, more specific

indicator of its interest in direct broadcast by satellite (DBS) to Britain was its participation in one of the losing consortia that bid for the British high-powered DBS franchise which BSB won.

Finally personalities may have mattered at News Corporation as well as at BSB, particularly the personality of Rupert Murdoch who had founded News Corporation and continued to control it financially and managerially. Murdoch, originally an Australian, was widely reputed to have a chip on his shoulder against Britain and its media establishment. As he himself put it at the press conference at which he announced the launch of Sky, "My contention is that broadcasting in this country has too long been the preserve of the old establishment and is deeply elitist in its thinking and approach to programming." It is conceivable that Murdoch derived nonpecuniary personal benefits from challenging BSB's upmarket "establishment" approach with a disestablishmentarian, downmarket one. From BSB's perspective Murdoch's widely broadcast attitudes could arguably have helped predict ahead of time that he would prove one of the more dangerous of the competitors that bid for but lost the British high-powered DBS franchise to BSB.

As far as the rewards to expanded competitor analysis are concerned, BSB might have behaved rather differently had it taken potential competitors more seriously, with important implications for its positioning at the time News Corporation announced the launch of Sky. In terms of programming, BSB might have moved earlier to tie up the British rights to the films of the major Hollywood studios: At the time of Sky's entry, it was close to signing agreements with most of the major studios but was holding out for access to films within six months of their release on video instead of the customary twelve months. In addition BSB might have reconsidered the minimal differentiation from the BBC that was implicit in the high-quality programming that

it was planning: Sky subsequently pursued a more differentiated position. The British government might have been dealt with differently as well: Rules could have been clarified, regulatory loopholes (e.g., indirect entry via a medium-powered satellite, as well as the possibility of cross-owning and cross-promoting British newspapers and television channels) could have been closed off, and better terms could have been bargained for because of potential competition (e.g., insistence on the rights to all five rather than just three high-powered channels). To deal more directly with potential competitors, BSB might have prepositioned itself better by accelerating its launch date and slimming down a cost structure that was widely viewed as bloated. It could also have been less exuberant in its forecasts about the demand for satellite television in Britain. While some of these steps could still have been taken after Sky's entry, and were, the delay generally reduced their effectiveness, confirming the rewards to anticipating rather than merely reacting to competitors.

To summarize this section, use of an expanded framework for competitor analysis might have helped BSB to assign News Corporation a position toward the head of the queue of potential entrants. If BSB had registered ahead of time the threat from News Corporation in particular and from potential competitors in general (it was aware, after all, of the planned launch of the Astra medium-powered satellite), it might have taken a host of actions that could either have deterred Sky's entry or positioned BSB better to deal with postentry competition. Instead, BSB appeared to ignore potential competition and to preposition itself as an inefficient "fat cat." Note the implication that careful competitor analysis—including but extending beyond the theoretical analysis of no/low-fat models—can have implications for internal organization as well as for external interactions.

7.6 Summary

Compared to the preceding chapters, this chapter has placed more emphasis on the limits of game theory than on its uses. Two principal difficulties arise. The first difficulty, which was flushed out by the empirical analysis, is that it may not always be possible to treat competitors as unitary actors out to maximize their own payoffs. This is partly due to the fact that organizations are not monadic; they consist, instead, of various constituencies with diverse interests (e.g., shareholders vs. managers in the case of BSB). It may not always be possible, let alone likely, for organizational rules to aggregate such diversity into a well-behaved objective function. In addition there is always the possibility of idiotic behavior, pure and simple. Scouting both possibilities requires a detailed analysis of internal organization and is aided by Selznick's (1957) observation that commitments to acting in particular ways are built into organizations.

The second difficulty with standard game theory, which was flushed out by the theoretical analysis, is that even if competitors can, to a first approximation, be treated as unitary, payoff-maximizing players, the concept of strategic equilibrium may unduly restrict the set of possible outcomes by ruling out strategic uncertainty. Once one grants the existence of strategic uncertainty, the scope of the probability assessments that are in order extends to encompass rivals' strategies as well as the structural parameters of their payoff functions. The expanded framework for competitor analysis described in the last section of this chapter is meant to help with such direct assessments of competitors' strategies. While economic incentives cannot be ignored, neither can behavioral considerations—a topic that will be revisited in the next chapter.