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Making game theory work for managers

A new model, rejecting solutions optimal only for a single precisely defined future, generates answers representing the best compromise between risks and opportunities in all likely futures.

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In times of uncertainty, game theory should come to the forefront as a strategic tool, for it offers perspectives on how players might act under various circumstances, as well as other kinds of valuable information for making decisions. Yet many managers are wary of game theory, suspecting that it's more theoretical than practical. When they do employ this discipline, it's often misused to provide a single, overly precise answer to complex problems.

Our work on European passenger rail deregulation and other business issues shows that game theory can provide timely guidance to managers as they tackle difficult and, sometimes, unprecedented situations. The key is to use the discipline to develop a range of outcomes based on decisions by reasonable actors and to present the advantages and disadvantages of each option. Our model shifts game theory from a tool that generates a specific answer to a technique for giving informed support to managerial decisions.

Several factors in today's economic environment should propel game theory to a prominent place in corporate strategy. The global downturn and uncertain recovery, of course, have prompted radical shifts in demand, industrial capacity, and market prices. Some companies, emboldened by the crisis, have tried to steal market share. New global competitors from emerging economies, particularly China and India, are disturbing the established industrial order. They use new technologies and business models and even have novel corporate objectives, often with longer-term horizons for achieving success.

These uncertainties can paralyze corporate decision making or, perhaps worse, compel managers to base their actions on gut feelings and little else. Game theory can revitalize and contribute clear information to decision making—but only if its users choose a set of inputs detailed enough to make the exercise practical and analyze a range of probable scenarios.

Decades old—and misunderstood

Game theory as a management tool has been around for more than 50 years. Today, most university business students are introduced to the idea through the classic "prisoner's dilemma." This and similar exercises have instilled the idea that game theory generates a single solution representing the best outcome for reasonable players.

In academic settings, game theory focuses on logically deriving predictions of behavior that are rational for all players and seem likely to occur. It does so by seeking some form of equilibrium, or balance, based on a specific set of assumptions: the prisoners aren't aware of each other's actions, can give only one answer, and so on.

But the real world is messier than the neat environment of the prisoner's dilemma, and game theory loses some traction when faced with practical, dynamically evolving business problems. Companies using this approach often fail to strike the right balance between simplifying a problem to make it manageable and retaining enough complexity to make it relevant. In addition, decision makers often get a single proposed solution without understanding clearly the assumptions that went into its formulation. This problem is especially troublesome because solutions that seek a universal equilibrium among players in a sequence are sensitive to the initial conditions presented and to the assumptions used in deriving an answer.

We have developed a model that addresses these objections. Instead of predicting a single outcome, with all factors balanced, the model first generates a narrow set of strategic options that can be adjusted to account for changes in various assumptions. Instead of solving an individual game, the model automatically involves a sequence of several games, allowing players to adjust their actions after each of them, and finds the best path for different combinations of factors. As one result, it supports executive decisions realistically by presenting managers with the advantages and disadvantages of the strategic options that remain at each stage of the progression. In a second step, the model finds the “best robust option,” considering its upside potential and downside risks under all likely scenarios, assumptions, and sensitivities as time elapses. This approach is different from attempts to look for equilibrium in an artificially simplified world.

Let’s say, for example, that two companies in the global machinery market face an attacker from China planning to open its own multipurpose factory. Depending on myriad assumptions about cost structures, customer demand, market growth, and other factors, the best strategy in one scenario could be for the incumbents to cut prices. In a second scenario, using slightly different assumptions, it could be best to wait until the entrant acts and then to secure the greatest value by reacting appropriately.

Traditional game theory delivers the best answers and equilibriums, which could be completely different for each scenario. Then it tries to predict the most likely scenario. But you can’t analyze uncertainty away, and the traditional approach actually offers management a series of “snapshots,” not a recommendation based on the overall picture. Our model, in contrast, examines how assumptions and actions might change and looks at possible gains and losses for each player in a dynamic world. In the example of the machinery companies, the best robust option could be to leave room for the entrant in a particular niche, where the incumbents are weakest and there’s little risk that the entrant could expand into other segments.

Our model seeks to balance simplicity and relevance by considering a likely set of actions and their effect on important metrics such as demand and profit. Experience and an understanding of the various actors’ sensitivities to different situations guide the analysis. By considering only the most relevant factors, the model manages complexity and, at the same time, creates transparency around important break points for the key drivers. One such break point could be how strongly the market must react to an attacker's move before an incumbent's best strategy shifts from coexistence to counterattack.

The best way to understand the model is to examine it in action.

Game theory and European rail

After years of debate and delay, the deregulation of passenger railways in the European Union appears to be gaining momentum. Cross-border passenger service is to be fully open to competition from January 2010. Some member states, including Germany, Italy, Sweden, and the United Kingdom, have taken the initiative and begun opening domestic long-distance passenger rail service to competition, as well.

The experience of other deregulated industries provides rail operators with some lessons, such as the futility of price wars, which generally destroy an industry's profitability. But the unique characteristics of rail make it exceptionally difficult to predict how competition will alter the playing field. In passenger rail service, for instance, network effects are prevalent, as routes connecting passengers to numerous cities and towns tend to be highly interdependent.

Certainly, new entrants will try to skim off some of the most profitable point-to-point routes. Despite significant upfront capital expenditures, these challengers will probably try to use lower operating costs to undercut the incumbents' fares. Beyond that, it remains to be seen how and where the attackers will attack and how incumbents will defend themselves.

Besides mutually destructive price wars, what options do the incumbents have? Should they rewrite their schedules to compete with the attackers' timetables head-to-head? Would it make sense for them to emphasize their superior service or to compete on price by stripping away frills? Should they concede some minor routes to the new entrants in hopes of limiting the damage or fight for every passenger?

To address these questions, the model we developed uses game theory to understand the dynamics of the emerging competition in long-haul passenger rail routes. It breaks down the complex competitive dynamics into a set of sequential games in which an attacker makes a move and an incumbent responds.

From the perspective of the attackers, the range of options available can be distilled into four main choices. The attackers could imitate the incumbents by providing similar or identical service. They could go on the offensive with a more attractive service—for instance, one that is cheaper or more frequent. They could specialize by offering a niche service, probably only at peak hours, that isn't intended to compete with the incumbents across the schedule. Finally, they could differentiate by providing a clearly distinctive service, such as a low-cost offer focused on leisure travelers, with suitable timetables and less expensive, slower rolling stock.

Likewise, the range of responses available to incumbents on each route under challenge can be broken down to their essence: to ignore the attackers by not reacting at all; to counterattack by contesting the entry through changes in price, frequency of service, and schedules; to coexist by ceding some routes and learning to share them; or to exit a route by stopping service on it.

These initial steps in setting up a game theory model are straightforward. The crucial element is to create a list that is both exhaustive and manageable. But the world is dynamic, and the payoffs for each player depend heavily on the details. Four factors, which must also be included in the rail model, can significantly affect the outcome.

- *Total changes in demand*. What will happen to demand with each move by an attacker and response by an incumbent? When offered a broader, more comprehensive choice of rail links, passengers could change their behavior—for instance, travelling by train instead of car or plane.

- *Cost differences*. New players typically have significantly lower operating costs than incumbents, which, however, generally enjoy economies of scale. But a higher degree of complexity and public-service obligations, such as maintaining uneconomical routes, often negate this advantage.

- *Network advantages*. Incumbents almost always have a network advantage, since attackers rarely replicate an incumbent's entire system. (Many routes, intrinsically unprofitable by themselves, are valuable only as feeders to the larger network.) Passengers generally prefer seamless connections—a preference that plays to the incumbents' strengths, especially to and from points beyond the major routes.

- *Price sensitivity*. Attackers typically charge lower fares, and the degree of difference needed for passengers to switch lines or modes of transport (from cars to trains, for instance) is critical to the outcome.

In the common approach to game theory, analysts look at dozens of permutations of actions and reactions, choosing those they feel are consistent and mutually balanced, as well as most likely to occur. Then they make assumptions about these or other factors. The result is a solution, with one particular set of assumptions, derived from all the interests of all the players. The solution could, for instance, be to fight the new entrant tooth and nail on all fronts.

But in looking at the problem, we found several conditions in which the players' interests could be seen as consistent and mutually balanced. Just as interesting, the results were sensitive to our initial assumptions: in other words, when we slightly modified an assumption about, say, changes in demand, the results would be very different. From this perspective, our model resembles a business simulator, allowing executives to get a clear understanding of the likely evolution of competition under differing conditions. It helps companies to generate the best option as the moves of competitors become clear.

The outcome of the rail analysis

What did the model say about European passenger rail?

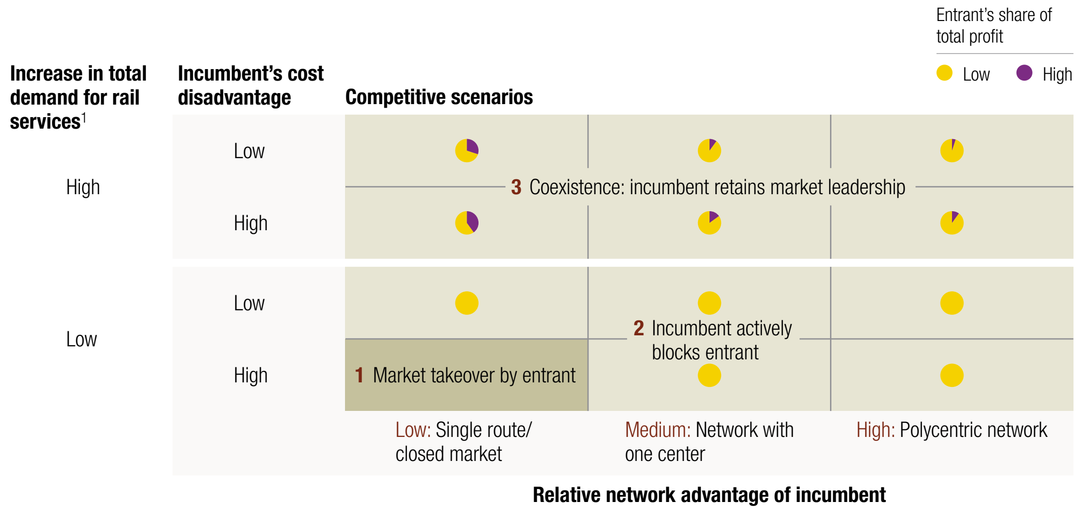
Consider, first, one set of conditions. In this scenario, the incumbent operates a fairly large network and has enjoyed monopoly advantages—in particular, relatively high profits. But because of the monopoly legacy, the incumbent suffers from operational inefficiencies and a sizeable cost base. Overall demand is elastic: customers are likely to travel more by rail if service improves and quite likely to accept low-price offers. A new company with a substantially lower cost base considers cherry-picking a few of the more attractive routes by offering improved service.

This model suggests that although the attacker enjoys lower costs and seems to have a favorable starting position, it will probably take only a sliver of market share, and that thanks largely to a general increase in rail use. The incumbent will remain dominant. Seeing the likely outcome of the attacker's specialized or niche entry, the incumbent's executives should conclude that a strategy of tolerance would be best. Only a small share of the market is at stake, and the incumbent could lose much more if it engaged in a costly battle for this sliver—for instance, by waging a destructive price war or using other expensive tactics. If the attacker is more aggressive, the incumbent's best answer would be to fight back with tactics including aggressive price competition, targeted marketing activities, and more frequent and better service on the routes under attack. Note, however, that this would substantially lower profits for both players.

To cover the full range of possibilities, the model can manipulate each variable. Under certain circumstances (if the demand reaction is muted, the incumbent's cost disadvantage high, and its network advantage small) entrants have the inside track and could probably take control of the market. When circumstances favor the incumbent a little more (because its network advantage is stronger or its cost disadvantage smaller) it will probably have strong incentives to lower prices preemptively to prevent a possible attacker's entry.

Exhibit 1

Three scenarios



[1] Degree of change in rail's share of all travelers (compared with those opting for other forms of transport) as a result of new entrant in market.

If conditions are more ambiguous, the incumbent may have to settle for coexistence, although it can probably retain market leadership. The attacker's share of the industry's profits would vary significantly, depending mainly on the incumbent's network advantage (Exhibit 1).

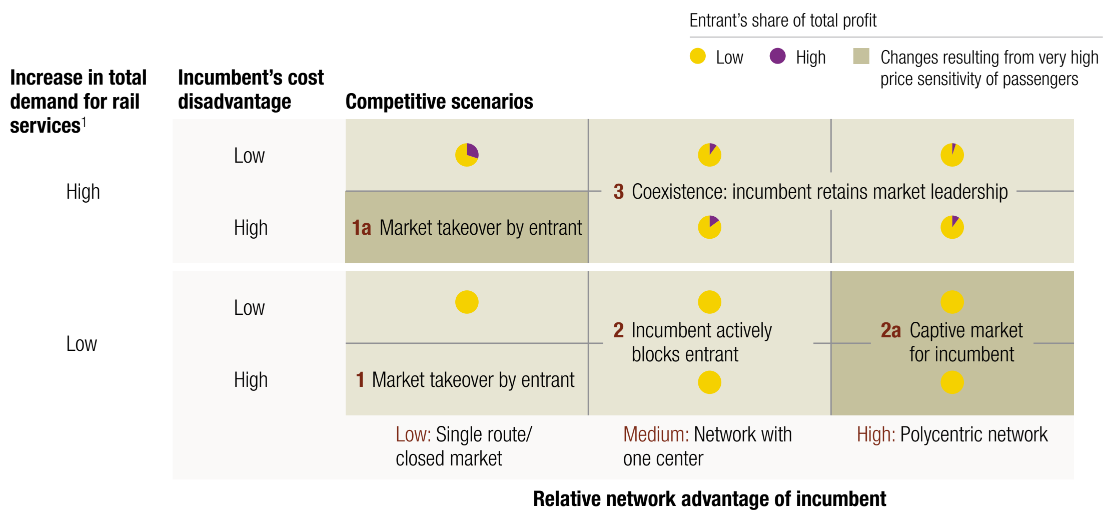
When we run the European passenger rail model through an array of different situations, a critical factor appears to be the way demand reacts to liberalization. Will the new offerings seduce travelers to take trains rather than cars or jetliners, or will overall demand remain stagnant, leaving rail companies to battle for an unchanged pool of customers (Exhibit 2)?

If the attacker's entry doesn't stimulate demand, two operators cannot profitably share most routes: high fixed costs make many of them natural monopolies supporting only a certain level of capacity. A weak incumbent—for instance, one with major cost disadvantages or few network benefits—could be squeezed out by an agile attacker. A strong incumbent could cut fares before the attacker committed itself to any investment, dissuading it from making the challenge. In the end, the competitors will face a winner-takes-all situation, with only one left in the market.

When rail demand can be stimulated, players will probably coexist profitably. But the model suggests that even when the attacker enjoys the best conditions, the incumbent is

Exhibit 2

The influence of pricing



[1] Degree of change in rail's share of all travelers (compared with those opting for other forms of transport) as a result of new entrant in market.

likely to retain market leadership. Reasonable attackers will have an incentive to enter only on a small scale that the incumbent can usually tolerate. More aggressive moves from either side would trigger ruinous price wars or service expansions, destroying the industry's overall profitability.

Finally, at each moment, incumbents almost always have one best robust option that conserves much more of their profits than any other course. Quite often, deviating from that option reduces the entire industry's profits significantly. But unlike a solution based on traditional game theory—a solution optimal only for a single precisely defined future—our model generates an answer that represents the best compromise between risks and opportunities across all likely futures. Unlike the answers suggested by traditional game theory, this one does not require all competitors to behave according to a narrowly defined rational equilibrium at each moment. The transparency of our approach helps executives understand the break points of a strategy: how much reality must differ from its assumptions before a new strategy is needed.

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Although we focus here on European passenger rail, our model shows how game theory can be applied to many complex environments and produce results informing many strategic decisions. We've applied the model to other problems, with similarly enlightening

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results. In health care, for example, we examined the dynamics of the commoditization of certain drugs—in particular, after Asian manufacturers offered higher-quality versions of them. We also looked at the strategic options of companies in the chemical industry in the wake of recent overcapacity and reduced demand. Game theory is a powerful framework that enables managers to analyze systematically the ties among interactions between actors in a market and to develop appropriate competitive strategies. But it's helpful only if executives expect a tool that helps them make informed decisions based on a range of market actions by each player, not a single answer that solves the whole riddle.

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