2004

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MANAGEMENT SCIENCE
Vol. 50, No. 10, October 2004, pp. 1319–1333
ISSN 0025-1909 | EISSN 1526-5501 | 04 | 5010 | 1319

DOI 10.1287/mnsc.1030.0152

How Do Value Creation and Competition Determine Whether a Firm Appropriates Value?

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How does competition among economic actors determine the value that each is able to appropriate? We provide a formal, general framework within which this question can be posed and answered, and then provide several results. Chief among them is a condition that is both required for, and guarantees, value appropriation. We apply our methodology to (i) assess the familiar notion that uniqueness, inimitability, and competition imply value appropriation, and (ii) determine the value appropriation possibilities for an innovator whose unique discovery is of use to several others who can compete for the right to use it.

Key words: value appropriation; competition; competitive advantage; imitation; innovation
History: Accepted by Daniel Levinthal, business strategy; received June 1, 2001. This paper was with the authors 3 months for 1 revision.

1. Introduction

A fundamental question in business strategy is: How does competition among economic actors determine the value each appropriates? There are many approaches to answering this basic question. One comparatively formal one is based on the familiar industrial organization continuum in which, at one extreme, perfectly competitive firms surely do not appropriate, and at the other, monopolists surely do (at least under some assumptions—more on this below). What happens between competition and monopoly is less clear, but intuition that the more the situation seems monopoly-like, the better the prospects of appropriation are, is commonplace; see, e.g., Saloner et al. (2001, Chapter 7). Less formal, but highly influential, the resource-based view equates the ability to appropriate with ownership of something valued by others and in limited supply. For example, Collis and Montgomery (1998, p. 39) say: "…the resource-based view argues that profits can be attributed to the ownership of a scarce resource." These and other familiar approaches to answering the basic question set out above appear to be founded on the notion that appropriation is fostered by control over some useful entity—a patent, a new process, a unique organization, special human capital assets, location—for which there is competition.

Despite the volume of research on this topic, there is no general, formal framework to address this fundamental question or to unify and assess the many existing approaches. In this paper, we present such a framework, use it to provide a complete characterization of the features of a competitive interaction that ensure an agent can appropriate, and provide insights into the inner workings of a variety of familiar ideas from strategy; for example, what is "imitability," and how does it limit appropriation possibilities?

We show that (i) there is a feature of competition that is required for a firm to appropriate, but does not guarantee this; (ii) there is a different feature that actually guarantees appropriation, but is not required for it; and (iii) yet another feature is both required for, and guarantees, appropriation; it also yields a new set of very intuitive conditions that are jointly necessary. We employ these results to explore a pair of related strategy issues in which the role of competition is central. First, do uniqueness, inimitability, and competition assure appropriation? Second, is a technology innovator assured appropriation when there are multiple firms that value the technology, but none can reproduce it on their own?

We also show that in any given economic interaction, there are both a minimum and a maximum level of appropriation guaranteed by the alternatives available to the various actors. When one's maximum and minimum differ, any level of appropriation in between is possible. In this case, something other than competition (i.e., "bargaining") determines an individual's precise level of appropriation. We focus primarily on the minimum and, when it exceeds the normal rate of return (i.e., implies supranormal profits), say the corresponding individual has a *competitive advantage*.[1]

Why this focus? First, an agent's having competitive advantage, as we have defined it, suffices for that agent to participate in the value creation activity. Next, having a competitive advantage implies that an individual need not rely on whatever bargaining might entail to achieve supranormal profits. (This is not to say that good bargaining would not enhance appropriation, just that this may not be needed for appropriation.) Finally, the determinants of the minimum, once uncovered, reveal a lot about how competition leads to value appropriation. The avenues through which alternatives foster or work against appropriation turn out to be quite subtle, and the implications sometimes surprising.

Formally, the framework we study is a general coalitional game with transferable payoff. This setup has a long history in game theory and has been studied extensively; Osborne and Rubinstein (1994) provide a good introduction. We are not, however, simply adapting results from this literature. Our work in this paper and related research makes several novel contributions to game theory; we elaborate below. At the same time, we also attempt to contribute by making accessible to those whose specialty is not game theory, some very informative, but mathematically elaborate, material.

The structure of this paper is as follows. In the balance of this section, we comment on where this paper fits into the game theory and strategy literatures. In §2, we provide examples that motivate the ingredients of our approach and suggest the kind of general results we later develop. In §3, we describe our framework; the main results appear in §4. We close with the applications to uniqueness/inimitability/competition and technological innovation in §5, and a discussion of some subtleties and limitations of our approach in §6.

1.1. Literature

Brandenburger and Stuart (1996) were the first to suggest that coalitional games can fruitfully be applied to study foundational issues in business strategy. Our paper makes several contributions to both strategy and game theory, and so we discuss the relevant literature in both fields.

[1] This terminology distinguishes between an agent earning supranormal profit and those features of the economic situation that cause this. We emphasize this distinction because, as our results show, there are many different ways in which the structure of competition can lead to supranormal profits. The common practice of loosely equating competitive advantage with features thought to deliver it can be misleading.

Game Theory. Economists have long known that the set of equilibrium payoffs for an individual in a coalitional game is a closed interval, but little is known about what determines the bounds of this interval in a general game. Shapley (1971) showed that in a restricted class of games (convex), the bounds on a player's equilibrium payoff are equal to the lowest and highest contribution of that player to some group. MacDonald and Ryall (2003a) provide the first complete characterization of the upper and lower bounds on individual equilibrium outcomes for general coalitional games with transferable payoff.

In this paper, we define three concepts that emphasize different dimensions of competition—*marginal product*, *minimum residual*, and *minimum total value*—and then link them to value appropriation. The latter two definitions are new. Of the results that follow, Proposition 1 is a well-known result in coalitional game theory; Proposition 3 is from MacDonald and Ryall (2003a); Proposition 4 is a simplified version of a result in that paper; and Propositions 2, 5, and 6 are new.[2]

Brandenburger and Stuart (2003) is especially relevant. They develop a hybrid noncooperative/coalitional formalism called a *biform* game. Specifically, in the first of two stages, agents acting noncooperatively make choices that determine the structure of the second-stage coalitional game. For example, firms might make capacity choices in the first stage, and later, given capacities, interact in the "free-form" way the coalitional structure emphasizes. Brandenburger and Stuart develop an axiomatic approach to resolving the bargaining problem—one that implies a unique expected outcome within the agent's *range* of possible equilibrium payoffs in the coalitional game. Our work complements theirs by showing how competition determines this range, and expands the applicability of the biform model by shedding light on, e.g., how a firm's increasing capacity alters the range of possible equilibrium payoffs it faces. We elaborate briefly in §6.

Strategy. One key objective of strategy research is to identify general features of the economic environment that determine how competing firms appropriate value. For example, Porter (1980) says, "The essence of strategy formulation is coping with competition," and goes on to enumerate five "forces" that determine the relative "intensity" of competition in an industry, which in turn determines the performance prospects for its members. Wernerfelt (1984) analyzes the relationship between firm "resources" and profitability, and argues that resource "position barriers"

[2] The proof of Proposition 2 is straightforward and appears in §4.2. Proofs of Propositions 5 and 6 are available on the *Management Science* website (mansci.pubs.informs.org/ecompanion.html).

are associated with high profits. Barney (1991, p. 101) examines "the role of idiosyncratic, immobile firm resources in creating sustained competitive advantage," arguing that ownership of resources that are "valuable," "rare," and "imperfectly imitable" implies sustained performance advantage.[3] This focus is also articulated in modern strategy texts. Collis and Montgomery (1998, p. 5) tell us that value creation is the "ultimate" purpose of corporate strategy and that one of the "most fundamental" questions of strategy is, "What makes competitive advantage sustainable?" Saloner et al. (2001) say that a firm must not only be able to create value, but "In order to prosper, the firm must also be able to capture the value it creates" (p. 39).

Evidently, identifying general principles leading to value appropriation under competition is an important issue in business strategy. We address this same issue and are motivated by some of the ideas and phenomena raised by those mentioned above. However, our approach differs in an essential way: We provide a formal, general description of a strategic interaction, an agent's role in it, and how alternatives available to individuals influence appropriation. Throughout, the reader can determine: what our theory assumes, whether it is internally consistent, to which class of situations it applies, and so on. This precision and specificity allow us to give unequivocal definitions of, and to conduct logical tests on, some of the important ideas discussed informally in the work mentioned above. Indeed, we provide a precise, general answer to the question, "When is an agent guaranteed appropriation under competition?"

While it is easy to argue that methodological debates rarely produce much of value, we think the sections that follow persuasively establish the utility of our formalism in understanding foundational issues in strategy. In addition to providing answers to basic questions, our analysis uncovers subtleties of competition that sometimes have surprising implications. For example, we show that valuable, rare, and imperfectly imitable resources are, in general, neither necessary nor sufficient for sustained performance advantage. Conversely, we identify the types of situations in which these qualities are important. We view our work as a companion to the informal theory that precedes it, and a natural next step in strategy's maturation as a field built upon a logically consistent body of theory and evidence. In MacDonald and Ryall (2003b), we explain and illustrate how our formalism can be employed to assist in uncovering and evaluating opportunities for value creation and appropriation—what data are required, how the requisite calculations can be carried out, how the calculations can be used to quantify the value of new initiatives, etc.

[3] Many strategy theorists trace their intellectual roots to Penrose (1959), who argued that firms should be viewed as unique bundles of productive resources; Peteraf (1993) surveys the early literature.

2. Examples

We begin with some simple examples that introduce the theoretical setup and behavioral hypotheses we analyze in detail below. The examples demonstrate some of the subtleties in the way agents' alternatives influence their ability to appropriate value, and illustrate the limits on the informativeness of some familiar models of markets. These examples are not intended to be realistic applications. Rather, they are intended to motivate why coalitional games are a useful way to study value appropriation under competition and to illuminate the power of agent's alternatives in shaping individual value appropriation.

Example 1 (Pure Bargaining). Consider a situation with one firm and one buyer, labeled F_1 and B_1. F_1 can produce one unit of its product at cost normalized to zero. B_1 seeks to purchase at most one unit of product, and doing so yields utility of \$1. Neither F_1 nor B_1 have any outside alternatives, so the only options available to F_1 and B_1 are to produce \$1 of value together, or not.

It is intuitive (and an implication of the model—see below) that \$1 of value will ultimately be created. However, as will become apparent from the sequence of examples, the alternatives available to agents play a key role in determining how much of the value any individual is guaranteed to receive. How does this work?

Suppose π_{F_1} and π_{B_1} are the values appropriated by F_1 and B_1, respectively; we will call $\pi \equiv (\pi_{F_1}, \pi_{B_1})$ a *distribution of value*. If π is a plausible candidate for an outcome given the assumed value creation possibilities, what conditions should π satisfy? One obvious condition is *feasibility*: Value distributed cannot exceed the value available for distribution. In this example,

$$\pi_{F_1} + \pi_{B_1} \leq 1. \tag{2.1}$$

The second condition, *stability*, describes how agents' alternatives structure their appropriation. We suppose agents have freedom of choice in their business dealings, so that if π specifies some agent to appropriate less than he could by acting on his own, this agent will simply go ahead and act on his own. (More generally, when there are more than two agents involved, we will also suppose that if any subgroup of agents could do better by acting on their own, they will.) In this example, stability implies three restrictions on π:

$$\pi_{F_1} + \pi_{B_1} \geq 1, \quad \pi_{F_1} \geq 0, \quad \text{and} \quad \pi_{B_1} \geq 0. \tag{2.2}$$

Because stability requires $\pi_{F_1} + \pi_{B_1} \geq 1$, and only \$1 can be distributed, any plausible outcome of this value creation opportunity must have $\pi_{F_1} + \pi_{B_1} = 1$; i.e., B_1 acquires a unit of Product 1 from F_1, and pays some fraction of \$1 for it. Do the alternatives available to the agents impose any further constraints? It is easy to see that the feasible and stable distributions involve *any* split of \$1 between F_1 and B_1. Consider the extreme outcome in which F_1 appropriates \$1, leaving B_1 with nothing. This distribution of value is stable because the only alternative available to B_1 is not consuming at all, and is also valueless to B_1. For similar reasons, $\pi_{B_1} = 1$ and $\pi_{F_1} = 0$ is also stable.

In this situation, the two agents have no value-producing alternatives to dealing with each other. Thus, however the dollar is split, it will *not* be the result of competition. This is why this case is referred to as "pure bargaining." Because either agent might appropriate nothing, we say that neither has a competitive advantage. One reasonable reaction to the possibility of such extreme outcomes is that (in any real economic interaction) they are unlikely to occur—F_1 and B_1 sharing the dollar more equitably, possibly as the result of some sort of bargaining, seems more plausible. We agree, but the important point is that there is nothing about the agents' alternatives that rules out these extreme outcomes.

Note that in this example, F_1 might be interpreted as a firm with a valuable product that none can imitate; i.e., as an instance in which F_1 controls a "unique, non-imitable, and valuable resource." Nevertheless, the competitive environment offers no guarantee that F_1 will receive a positive share of the value. Nor does it require F_1 to give up any value. The reason is that F_1's product, despite its uniqueness, etc., is not valuable without B_1. Depending upon what one assumes about how bargaining between F_1 and B_1 is likely to turn out, F_1 may or may not appropriate value.[4] From the perspective of this paper, the interesting point is that whatever F_1 ends up appropriating, the reason will not be that its product is unique, valuable, and inimitable.

Example 2 (Perfect Competition). Consider the same situation as in the previous example, but now assume F_1 and B_1 each have an outside alternative worth \$0.5. Now, stability requires that

$$\pi_{F_1} + \pi_{B_1} \geq 1, \quad \pi_{F_1} \geq 0.5, \quad \text{and} \quad \pi_{B_1} \geq 0.5,$$

which, given that there is just \$1 to distribute, imply $\pi_{F_1} = \pi_{B_1} = 0.5$. Thus, although the value appropriated in this interaction is strictly positive, it is exactly equal to the agent's "next-best" alternative. Not only does competition fully determine the distribution of value, no one appropriates supranormal profits.[5]

Example 3 (Capacity-Constrained Monopoly). In pure bargaining, the sole source of value is not F_1's product, but, instead, the interaction between F_1's product and B_1's enjoyment of it. Thus, it is intuitive that the addition of a second buyer, say B_2, who values the product as much as B_1 does, will generate competition that guarantees F_1 can appropriate some or all of the value.

Formally, as above, assuming F_1 has just one unit for sale, there is just \$1 to distribute. Because F_1 and either buyer can create \$1 in value on their own, stability requires both $\pi_{F_1} + \pi_{B_1} \geq 1$ and $\pi_{F_1} + \pi_{B_2} \geq 1$ which, with just \$1 to distribute, can only be satisfied by $\pi_{F_1} = 1$. Thus, the only stable distribution of value involves F_1 appropriating all value; i.e., one buyer acquires a unit of the product and pays \$1 for it. Intuitively, if, for example, F_1 and B_1 were to share the \$1 equally, leaving B_2 with nothing, B_2 could offer to displace B_1 and accept just \$0.4, paying \$0.6 to F_1, who would happily accept this offer. An analogous counteroffer can be found whenever F_1 appropriates less than \$1.

This is the classic case of capacity-constrained monopoly. Note that if F_1 has two units for sale (again without costs), because each buyer desires only one unit, the capacity constraint is irrelevant and there is no need for buyers to compete. In fact, the situation is effectively pure bargaining between F_1 and each buyer. This is an example of a general theme that we explore in depth below, that an abundance of resources—i.e., with the capacity constraint, there is just \$1 to distribute, but without it there is \$2—generally reduces the least an agent might appropriate.

Evidently, when there is competition to do business with an agent, that agent's appropriation prospects might improve. Let us pursue this point a little further. Our description of the value creation possibilities allows us to quantify the value each agent adds. Following Brandenburger and Stuart (1996), F_1's value-added is the difference between the value that could be created by all the agents, including F_1, and the value created by all the agents without F_1 (and likewise for B_1 and B_2). In keeping with the economics literature, we call this difference an agent's *marginal product*, and denote it by *mp* (subscripted to identify the agent as needed). An agent must have a positive marginal product for that agent to appropriate value; see Proposition 1. To see this, observe that if an agent for whom $mp = 0$ is imagined to appropriate some value, the others could, instead, simply ignore

[4] Lippman and Rumelt (2003) provide discussion of various bargaining notions for coalitional games.

[5] Makowski and Ostroy (1995) generalize this idea and demonstrate that it implies efficient, price-taking behavior in an economy.

Table 1 Full Appropriation Example

Group	Value	Group	Value	Group	Value
F_1, F_2, B_1, B_2	4	F_2, B_1, B_2	3	F_2, B_1	2
F_1, F_2, B_1	3	F_1, F_2	0	F_2, B_2	2
F_1, F_2, B_2	3	F_1, B_1	2	B_1, B_2	0
F_1, B_1, B_2	3	F_1, B_2	2	single agent	0

Table 2 Less-Than-Full Appropriation Example

Group	Value	Group	Value	Group	Value
F_1, F_2, B_1, B_2	3	F_2, B_1, B_2	2	F_2, B_1	2
F_1, F_2, B_1	2	F_1, F_2	0	F_2, B_2	2
F_1, F_2, B_2	2	F_1, B_1	1	B_1, B_2	0
F_1, B_1, B_2	1	F_1, B_2	1	single agent	0

that agent with no effect on the value produced, and then share what the agent was to appropriate. In the pure bargaining example, $mp_{F_1} = mp_{B_1} = 1$, so both F_1 and B_1 have the prospect of appropriating value. On the other hand, the same example shows that positive marginal product does not guarantee appropriation. In the capacity-constrained monopoly example, because F_1's participation is required for \$1 to be created, $mp_{F_1} = 1$. However, because either B_1 or B_2 can always be removed without harming the value creation opportunity, $mp_{B_1} = mp_{B_2} = 0$. Thus, only F_1 has any possibility of appropriating, and so appropriates all the value.

Example 4 (Full Appropriation). We now enrich the situation by adding a second firm, F_2. Assume each firm can produce two units of product, the first at zero cost and the second at a cost of \$1, i.e., increasing marginal cost. Assume buyers view the firm's products as perfect substitutes, and that each buyer obtains \$2 in value by consuming a unit of either firm's product, \$3 by consuming two units of product, and no additional value for consumption above two units. Enumerating the value creation alternatives available to the participants in this interaction, we have the results in Table 1. The value generated by all agents' participation is \$4. This is the value created when either each firm produces one unit and each buyer consumes one, or each firm produces two units and each buyer consumes two. Likewise, two firms and a buyer can generate \$3 by each firm producing one unit and the buyer consuming both, and so on.

In this example, every agent has $mp = 1$. Because an agent can never appropriate more than his or her marginal product, it follows that F_2, B_1, and B_2 can appropriate, at most, \$3 between them. This leaves a residual, $\$4 - \$3 = \$1$, that can only go to F_1. This is similarly true for all the other agents. Thus, each agent appropriates *exactly* \$1. Because everyone is guaranteed to appropriate their marginal product, this example is one of "full appropriation."

In this example agents' alternatives are so perfectly balanced that they imply a unique, feasible, and stable distribution in which all agents appropriate their marginal product—there is no room for bargaining. This situation is a very unusual one in that it occurs if and only if the sum of agents' marginal products equals the value that is available to be distributed.[6] Note that the perfect competition and capacity-constrained monopoly also have this feature, and so imply full appropriation.

Example 5 (None of the Above). Despite their familiarity and frequent application, the perfect competition and capacity-constrained monopoly scenarios, because they imply full appropriation, are quite special. In some situations of interest, the assumption that the value to be distributed is equal to the sum of the marginal products may be descriptive, but we know of no reason to expect that this is generally the case. When it is not, intuition based on these polar treatments of market structures can be misleading. In particular, the forecast that agents appropriate fully may not even be a logical possibility, and the importance of bargaining may be understated. A similar remark applies to pure bargaining, in which agents' alternatives only affect their appropriation possibilities trivially. Intuition based on this setup tends to understate the importance of agents' alternatives and the competition they imply.

The situation need only be slightly more complicated than the previous examples for the way appropriation possibilities shape appropriation to be more subtle. To see this, consider a simple duopoly model with vertical product differentiation and capacity constraints. Specifically, suppose each firm has one unit of capacity and each buyer values only one unit of consumption. Also, assume both buyers get \$2 from consuming F_2's product, versus just \$1 from $F_1's$. Ignoring costs again, the value creation possibilities are shown in Table 2.

First, is this situation well modeled by perfect competition or monopoly? Clearly, neither. F_2's marginal product is \$2, and the others' marginal products are all \$1. Thus, the sum of the marginal products exceeds the \$3 in distributable value, ruling out full appropriation, and along with it, perfect competition and monopoly. How about pure bargaining? For example,

[6] This is easy to see. If mp_i is distributed to i, and V is the total available for distribution, then feasibility requires $\sum mp_i \leq V$, whereas stability requires $\sum mp_i \geq V$; together $\sum mp_i = V$. On the other hand, suppose $\sum mp_i = V$. As usual, an agent cannot receive more than mp_i. However, it is also true that no agent can receive less. Were i to receive less than mp_i, that all value must be distributed means that some other agent, j, would have to receive more than mp_j. Proposition 1 tells us that this outcome cannot be both feasible and stable.

can it turn out that F_2 appropriates nothing? Clearly, not. Because F_2 and either buyer can create \$2 on their own, if F_2 appropriates \$0, stability requires each buyer to appropriate at least \$2. However, there is only \$3 to distribute. Thus, F_2 must appropriate. Overall, while this example is not unusual, it is not well described by any of the familiar cases set out above. A more general approach is needed.

We have already argued that F_2 must appropriate, but we can be much more specific. Indeed, F_2 must appropriate *at least* \$1 in any stable distribution of value. To see this, suppose F_2 appropriates only \$0.9, say by selling its unit of Product 2 to B_1 for \$0.9. This leaves B_2 to purchase a unit of Product 1. Suppose B_2 has made the best possible deal with F_1; i.e., B_2 pays \$0 for its unit of Product 1, and so appropriates all the created value, \$1. Even so, F_2 could offer to sell its unit of Product 2 to B_2 for \$0.95, and both F_2 and B_2 would prefer this to the contemplated distribution. Thus, F_2 cannot receive as little as \$0.9. The same argument applies whenever F_2 appropriates less than \$1.

Despite F_2's marginal product being \$2, all that competition ensures F_2 is \$1. The reason is that while buyers compete to buy from each firm, firms also compete to attract buyers. So F_2's superior product allows the competition among buyers to guarantee F_2 some of the created value, but the competition among firms limits how much F_2 is assured of appropriating.

What is the most F_2 can appropriate? It is easy to check that if F_2 appropriates \$2, and F_1 \$1, leaving nothing for the buyers, the buyers' alternatives do not allow them to avoid this outcome. Thus, the maximum F_2 can attain is \$2, his marginal product. Because the range of outcomes consistent with agents' alternatives leaves F_2 with a broad range of possibilities, i.e., $[1, 2]$, bargaining will play an important role in determining the final distribution of value.

These examples illustrate several points. First, the structure of one's competitive alternatives can guarantee an agent positive value appropriation irrespective of one's bargaining skill. Second, there are reasonable scenarios where the familiar full appropriation models are misleading—even in very simple interactions and under substantial simplifying assumptions, the forces of competition can work in subtle ways. The addition of more realism to these examples shows no sign of reversing this conclusion. Third, while the intuitive, well-known measure of individual value-added—marginal product—does provide useful insights, it does not capture the complete, competitive picture. Our goal is to develop some general principles regarding the relationship between competition and value appropriation. This is the task to which we now turn.

3. Theoretical Framework

In this section, we set out the general coalitional game framework used to derive our results. As in the preceding examples, the key element of the framework is a formal description of the value creation alternatives available to the agents participating in any strategic interaction.

3.1. Value Creation

Consider a strategic interaction among some agents, e.g., firms, suppliers, consumers, employees, regulators, etc. As in the examples, we need a way to describe various groups of agents and the value that might be created by these groups. Let the set $N \equiv \{1, 2, \ldots, n\}$ enumerate all the agents in the interaction; i.e., Agent 1, Agent 2, ..., agent n. Any subset of N (a "group") is denoted G; we call an arbitrary individual agent i. If G includes i, the group obtained by removing i is written G_{-i}; for example, N_{-i} is the group consisting of all agents except i. Likewise, if G does not include i, the group obtained by including i is written G_{+i}.

We have nothing new to say about the process leading to value creation opportunities. Thus, we treat agents' value creation possibilities as a primitive and leave this as general as we can. Specifically, for any group G, v_G is the value G can create independently of agents outside G. We emphasize that for any group G, while v_G is just one number, it can be employed to describe a multifaceted situation. That is, v_G represents the maximum value G can produce, implicitly accounting for limitations implied by information and agency considerations, transactions costs, configuration of productive resources, barriers to technology transfer, institutional structure, regulation, and so on. In particular, if members of G can "collude," then v_G is their greatest collusive payoff. If collusion is either prohibited, or impossible for agents to monitor and enforce, then v_G is their maximum noncollusive payoff. Without loss of generality, we assume the values are "normalized" so that v_G represents the value group G can generate in excess of the outside options of its members; that is, for all i, $v_{\{i\}} = 0$.[7] We also assume that including agent i in a group never reduces the value that group might generate. This implies that for any group G, $V \geq v_G$. Also, for any G including i, $v_G \geq v_{G_{-i}}$, specifically $V \geq v_{N_{-i}}$.

Given the set of players, N, let v be a vector whose components are v_G, for all the possible groups G; we

[7] For applications, the calculation of v_G is critical. In particular, attention must be given to the way value arrives over time, uncertainty, and any anticipated actions by other players. In MacDonald and Ryall (2003b), we detail the interpretation of v_G and how it can be calculated.

will call (N, v) a *strategic interaction*. Because $2^n - 1$ nonempty groups can be formed from N, v has $2^n - 1$ components. Also, because v_N appears frequently in what follows, we give it the special label V.

3.2. Impact of Agents' Alternatives

In §2, we defined a distribution of value, and discussed how feasibility and stability (formalized as (2.1) and (2.2)) constrain how value created may be distributed. In this section, we generalize these notions.

Given a strategic interaction (N, v), let π_i denote the amount of value obtained by agent i and refer to $\pi = (\pi_1, \ldots, \pi_n)$ as a *distribution of value*; where convenient we focus on agent i by writing $\pi = (\pi_i, \pi_{-i})$, where π_{-i} is a distribution of value among members of N_{-i}. The general version of (2.1) takes account of the fact that the group that creates the most value is the one including all agents:

$$\text{feasibility:} \quad \sum_{i \in N} \pi_i \le V. \tag{3.1}$$

The generalization of (2.2) requires that for each group G, no alternative, v_G, yields G more total payoff than the distribution of value:

$$\text{stability: for all } G, \quad \sum_{j \in G} \pi_j \ge v_G. \tag{3.2}$$

A couple of points are worth highlighting. First, because N is one of the groups referred to in (3.2), $\sum_{i \in N} \pi_i \ge V$. That is, altogether, at least V must be distributed among the agents. Together with (3.1), a feasible and stable distribution of value always distributes exactly V; i.e.,

$$\sum_{i \in N} \pi_i = V. \tag{3.3}$$

Second, it proves useful to observe that (3.2) can be stated as

$$\text{for all } G \text{ including } i, \quad \sum_{j \in G} \pi_j \ge v_G \quad \text{and} \quad \sum_{j \in G_{-i}} \pi_j \ge v_{G_{-i}}. \tag{3.4}$$

As in the examples, there may be many distributions of value that are both feasible and stable. What determines which distribution ultimately occurs? Both feasibility and the impact of agents' alternatives have already been taken into account. Thus, the third force determining how value can be distributed is the abovementioned "bargaining" process, a catchall for all the means—apart from the threat of exercising their strategic alternatives as embodied in (3.2)—that agents might employ to cajole one another into parting with value. Instead of making particular assumptions about how bargaining operates and focusing on the implied distribution(s) of value, we consider a distribution of value to be a plausible candidate for an outcome of an interaction if it is simply feasible and stable. Any such distribution is consistent with value creation and competition, but is not reliant on some arbitrary bargaining procedure. If π is a feasible and stable distribution of value, we will refer to it as an FSD.

4. Value Appropriation: General Principles

The value agent i appropriates depend on which FSD occurs; and typically there are numerous FSDs. From agent i's perspective, if all FSDs result in his receiving positive value, then no matter how bargaining ultimately determines precisely which FSD occurs, the nature of i's alternatives and the implicit competition for his participation in the value creation activity mean he is assured of appropriating some part of the created value. Thus, to emphasize the crucial role of an agent's competing alternatives, we say that agent i has a *competitive advantage* if $\pi_i > 0$ in every FSD.

If one considers all FSDs, the possible payoffs to any individual agent form an interval, which we designate $[\pi_i^{\min}, \pi_i^{\max}]$. That is, given the strategic interaction (N, v), there are FSDs in which i receives exactly $\pi_i^{\min}$, exactly $\pi_i^{\max}$, or any amount in-between. Thus, agent i's having a competitive advantage coincides with $\pi_i^{\min} > 0$.

In this section, we explore the features of the strategic interaction that yield competitive advantage. We begin with a well-known necessary condition, then use this to derive a new sufficient condition. We go on to provide a novel characterization (i.e., conditions that are both necessary and sufficient) of i having a competitive advantage, then develop a new set of simple, highly intuitive, jointly necessary conditions. The characterization emphasizes that how much value is created plays a key role in determining how that value is distributed. Perhaps counter to intuition, there is a clear sense in which a lot of value being created blunts the competition for an agent, thereby removing his competitive advantage. The jointly necessary conditions reveal the structure of the competition that can yield competitive advantage.

4.1. A Condition Necessary for Competitive Advantage

Brandenburger and Stuart (1996) emphasized the role that an agent's value-added plays in allowing value appropriation. This idea is relevant to, and consistent with, our results. In our notation, agent i's *marginal product*, mp_i, is the difference between V and the value that could be created by all agents other than i, $v_{N_{-i}}$, i.e.,

$$mp_i \equiv V - v_{N_{-i}}.$$

Because $v_{N_{-i}}$ is the maximum value that can be created without i, mp_i measures the incremental value i adds to the strategic interaction. It is easy to see that i cannot appropriate more than mp_i. That is, if the distribution of value resulted in i receiving more than his marginal product, there would be so little left to distribute among the other agents that they would find creating value on their own preferable.[8] So if i cannot appropriate more than mp_i, and if i is assured of appropriating—i.e., has competitive advantage—then he must also have a positive marginal product.

Proposition 1. *Given a strategic interaction, (N, v), positive marginal product is necessary for competitive advantage:* $\pi_i^{\min} > 0 \Rightarrow mp_i > 0$.

This result is intuitively appealing. However, it is also weak in the sense that while positive marginal product opens up the prospect of appropriating value, it in no way guarantees it; i.e., mp_i is necessary for competitive advantage, but not sufficient. The intuition is clear from the first example in §2. In that example, each of F_1 and B_1 has a positive marginal product, but both are needed to create value. Thus, stability demands only that all value be appropriated by F_1 and B_1, but this allows the possibility that one or the other will receive nothing. More generally, a positive marginal product does not mean that the competition implied by the structure of i's alternatives is such that i is assured appropriation.[9]

4.2. A Condition Sufficient for Competitive Advantage

Proposition 1 can be turned around to yield a sufficient condition for competitive advantage. To see how, recall the monopoly example in §2. There, $V = mp_{F_1} = 1$ and $mp_{B_1} = mp_{B_2} = 0$. Because \$1 must be distributed, and the structure of agents' alternatives (via Proposition 1) prevents either buyer from appropriating any value, the only FSD involves F_1 appropriating all the value. A similar notion holds in general. To see this, recall that V is the value that must be distributed among agents in any FSD, and define i's *minimum residual*, mr_i, by

$$mr_i \equiv V - \sum_{j \in N_{-i}} mp_j.$$

Because no agent can appropriate more than his marginal product, $\sum_{j \in N_{-i}} mp_j$ is the maximum amount of value that agents other than i can conceivably appropriate. Because V is the value to be distributed, mr_i is the least that can conceivably be left over for i. Therefore, if $mr_i > 0$, i is assured of appropriating, i.e., has competitive advantage.[10]

Proposition 2. *Given a strategic interaction, (N, v), positive minimum residual is sufficient for competitive advantage:* $mr_i > 0 \Rightarrow \pi_i^{\min} > 0$.

Why is having a positive minimum residual not necessary for competitive advantage? First, the calculation of minimum residual supposes that all players other than i simultaneously appropriate their marginal product. However, there may be no FSD with this feature. In Example 5, $mp_{F_1} = mp_{B_1} = mp_{B_2} = 1$, $mp_{F_2} = 2$, and $V = 3$, so it is not possible for all agents other than F_1 to appropriate their marginal product (indeed, $mr_{F_1} = -1$). Thus, the least that is left over for i is generally larger than mr_i, in which case i might be assured of appropriating value even though $mr_i \leq 0$. Second, minimum residual is determined solely by the value created in groups of size n and $n-1$. However, it may be that there are smaller groups, including i, which can create a great deal of value on their own. If such groups exist, resolving competition for i's participation may further limit how little i can receive, and yield competitive advantage despite $mr_i \leq 0$.

Proposition 2 reveals a subtle feature of the impact of agents' alternatives and the implied competition. Consider some agent j, other than i. Proposition 1 also tells us that agent j can never receive more than his marginal product, for this would make the prospect of creating value without j attractive to the others, including i. Thus, i's having to appropriate at least mr_i, as per Proposition 2, is due to the fact that if i were to appropriate less, some other agent j would have to appropriate too much to keep i and the others from simply creating value without j. Thus, i's guarantee of value appropriation is due to a blend of his value creation possibilities and the alternatives available to i and to the other agents.[11]

[8] Formally, suppose $\pi_i > mp_i$. Using the definition of mp_i and rearranging, we get $v_{N_{-i}} > V - \pi_i$. The right-hand side is the value that can be distributed to others if i appropriates π_i, and the left-hand side is the value others can appropriate without i.

[9] In fact, player i can have positive marginal product and *no* possibility of appropriation; i.e., $\pi_i^{\min} = \pi_i^{\max} = 0$. In the example following, the unique FSD distributes \$1 to each of F, B_1, and B_2, and nothing to B_3, despite B_3's marginal product being \$1.

Example with $mp_i > 0$ and No Competitive Advantage

Group	Value	Group	Value	Group	Value
F, B_1, B_2, B_3	3	F, B_1	2	B_1, B_2	0
F, B_1, B_2	2	F, B_2	2	B_1, B_3	0
F, B_1, B_3	2	F, B_3	0	B_2, B_3	0
F, B_2, B_3	2	B_1, B_2, B_3	2	single agent	0

[10] The assumption that there is at least one FSD implies $mr_i \leq mp_i$. If $mr_i > mp_i$, there are no FSDs.

[11] Brandenburger and Stuart (1996, pp. 15–18) suggest four "value-based" strategies for creating strategic situations with "favorable

4.3. Characterization of Competitive Advantage, and Jointly Necessary Conditions

The marginal product and minimum residual concepts provide insight into the sources of competitive advantage, and Propositions 1 and 2 sometimes give a clear answer about whether agent i has one: "yes" if $mr_i > 0$, and "no" if $mp_i = 0$. However, in many cases the structure of value creation is not so extreme; i.e., $mr_i \leq 0$ and $mp_i > 0$. When this occurs, Propositions 1 and 2 do not settle the question of whether an agent has a competitive advantage. We now provide a more elaborate, but complete, description of the feature of the strategic interaction that is both necessary and sufficient for competitive advantage, and that allows us to highlight how an agent's alternatives, and the implicit competition for his participation, work to yield or undermine competitive advantage.

Before developing the characterization, it is useful to start by revisiting Example 5. In that example, F_2 has competitive advantage and, in particular, is assured of appropriating at least \$1. The argument is that because F_2 and either buyer can create \$2 of value on their own, any FSD must result in F_2 and either buyer appropriating at least \$2 between them. Supposing F_2 is to appropriate \$0, each buyer must then appropriate at least \$2. However, there is only \$3 to distribute—not enough. Thus, F_2 must appropriate more than \$0, indeed, $\pi_{F_2}^{\min} = 1$. Intuitively, any division of \$3 between the buyers leaves one, or both, in the position of being able to do better by creating value on his own with F_2. In this sense, if F_2 is to appropriate \$0, buyers compete to act on their alternative with F_2. F_2's appropriating at least \$1 is the only way to resolve this competition while distributing a total of just \$3.

Now modify the example slightly by assuming there is a network externality in which each buyer's enjoyment of either product increases if the other buyer consumes the other product. The only entry in the table that is altered by this change is the \$3 figure, because the group comprising both firms and both buyers is the only one in which both buyers end up purchasing. Suppose the value created this way is \$4. It is easy to check that the distribution of value in which each firm appropriates \$0 and each buyer appropriates \$2 is an FSD; i.e., $\pi_{F_2}^{\min} = 0$ and F_2 no longer has competitive advantage. The introduction of the network externality does not change the fact that F_2 and either buyer must appropriate at least \$2 between them, so that if F_2 is to appropriate \$0, each buyer must appropriate \$2; the competition to create value with F_2 is exactly as before. However, the extra value created by the network externality allows this competition to be resolved by each buyer appropriating \$2, leaving F_2 with no competitive advantage.[12]

These examples suggest two closely related ways to look at what determines whether agent i has competitive advantage. First, if enough value is created, as occurs in the network externality example, value can be distributed among the other agents so that even if i is to appropriate nothing, no group can improve by creating value on its own with i. When this is so, i cannot be assured of appropriation, and so does not have competitive advantage. Our characterization formalizes this idea. Second, if i has competitive advantage, as in the example without the network externality, the reason is that if i is to appropriate nothing, some sort of competition to act on alternatives along with i arises, and this can only be resolved by i appropriating. Our jointly necessary conditions uncover, in a very general way, the sort of competitive setting that is needed for competitive advantage.

4.3.1. Minimum Total Value. Our characterization focuses on whether the value to be distributed among agents, V, is sufficient for the existence of FSDs in which agent i appropriates 0, i.e., whether $\pi_i^{\min} = 0$. The way we approach this is to calculate the smallest total value consistent with the existence of FSDs in which i appropriates 0, and then simply compare V to this smallest value.

Suppose that π is an FSD in which i does not appropriate value; i.e., $\pi_i = 0$. If $\pi_i = 0$, the stability conditions, (3.2) and (3.3), imply π must satisfy

$$\sum_{j \in N_{-i}} \pi_j = V, \tag{4.1}$$

and

$$\text{for all } G \text{ including } i, \quad \sum_{j \in G_{-i}} \pi_j \geq v_G. \tag{4.2}$$

asymmetries." They do not define favorable asymmetries, but Proposition 2 may have something to say about what they had in mind. The condition $mr_i > 0$ can be rearranged to $mp_i > \sum_{j \in N_{-i}} mp_j - v_{N_{-i}}$. Thus, i has competitive advantage if his marginal product is sufficiently large *relative to* the marginal products of others. It follows that actions yielding this sort of asymmetry are sufficient for competitive advantage.

[12] Although beyond the scope of this paper, note that this example, and its network externality extension, might be employed to think about how a firm might, or might not, benefit from introducing a product with network externalities or complementarities with others' products. These externalities are valuable, and so offer the firm the possibility of value appropriation. However, realization of the benefits of the externality requires the participation of others. As the example shows, the impact of this may be to blunt competition in a way that makes it less effective in fostering value appropriation. Thus, a firm's introducing a product of this kind may create value, but make competition less important and bargaining more important in determining who appropriates that value. Considerations of this sort figure prominently in the implementation-oriented discussion in MacDonald and Ryall (2003b).

Condition (4.2) is simply (3.4), taking account of the assumption that $v_G \geq v_{G_{-i}}$, and the fact that when $\pi_i = 0$, $\sum_{j\in G} \pi_j = \sum_{j\in G_{-i}} \pi_j$. Intuitively, when $\pi_i = 0$, any group that is not interested in acting on its alternative with i is also not interested in acting on its alternative without i. Because $\pi_i = 0$, (4.1) requires that V be distributed among players other than i.

Thus, whether there is any FSD in which i appropriates 0 boils down to whether it is possible to distribute V among agents in N_{-i} while satisfying both (4.1) and (4.2). To answer this question, define the *i-minimum total value* by

$$mv_i \equiv \min_{\pi_{-i}} \left\{ \sum_{j\in N_{-i}} \pi_j \,\middle|\, \text{for all } G \text{ including } i, \sum_{j\in G_{-i}} \pi_j \geq v_G \right\}.$$

The i-minimum total value is the smallest value that can be distributed among N_{-i} without making the alternative of acting on its own attractive for any group including i, despite $\pi_i = 0$. Whether agent i has competitive advantage boils down to whether the value that can be distributed, V, is great enough to be distributed in such a manner.

Proposition 3. *Given a strategic interaction,* (N, v), *i has competitive advantage if and only if mv_i exceeds V:* $\pi_i^{\min} > 0 \Leftrightarrow mv_i > V$.

Proposition 3 exposes the two opposing forces determining whether i appropriates value. To see what these forces are, return to (4.1) and (4.2). The better the alternatives available to groups including i, the more value must be distributed to agents to encourage them to forego these options if $\pi_i = 0$. This puts upward pressure on the least created value that can be stably distributed when $\pi_i = 0$. On the other hand, the more value there is, the easier it is to find a way to distribute it so as to preserve stability despite $\pi_i = 0$. Indeed, because mv_i is finite, there is always some level of V that results in i's not having a competitive advantage. In this sense, no matter what they look like, the structure of alternatives available to agents can never, by themselves, yield competitive advantage.

4.3.2. Structure of Competition. Proposition 3 is a complete description of the features of a strategic interaction that result in an agent having competitive advantage. Loosely, an agent has competitive advantage when, and only when, his failing to appropriate would necessarily unleash competitive forces that can never be satisfied if he does not appropriate. We can say something about the nature of these forces. To see the idea, recall Example 5. In that example, competition among buyers gave F_2 competitive advantage. What features do these competing groups have? First, each can produce more value with F_2 than without him, i.e., \$2 versus zero. This opens up the prospect of these groups competing for F_2. Second, no other agent is included in both groups, so that F_2's appropriating is the only way this competition might be resolved (more on this below).

Proposition 4. *Given a strategic interaction,* (N, v), *agent i has competitive advantage only if there is a collection of distinct groups,* $\mathbf{G} \equiv \{G_1, G_2, \ldots\}$, *each of which excludes agent i and does not include every other agent, with the features*

1. Potential competition. *There are at least two groups in G that are strictly more valuable if i is included*:

$$\textit{for some } G \textit{ and } G' \textit{ in } \mathbf{G}, \textit{ both } v_{G_{+i}} > v_G \textit{ and } v_{G'_{+i}} > v'_{G'}.$$

2. Uniqueness. *No agent is included in every group in* $\mathbf{G}$.

The intuition for these conditions is straightforward and related to the familiar notion that an agent's making a unique and valuable contribution will lead to value appropriation. The first condition states that among the groups excluding agent i, there must be at least two that are more valuable if i is included. The groups G_{-i} and G'_{-i} are then candidates for competing for i in exactly the manner described above. For this reason, having just one such group ensures no competitive advantage. Thus, the first condition may be interpreted as saying that competitive advantage requires the potential of competition for i. The second condition follows from the fact that if there is an agent j that is included in every one of the groups that might compete for i, the competition is effectively for the *pair* i and j. When this occurs, i and j are, in effect, in a pure bargaining situation, and divide whatever value competition allows them jointly to appropriate; thus, neither has competitive advantage.[13]

Proposition 4 suggests an interesting observation. If agent i has competitive advantage, there may be many ways in which competition ensures this. That is, were agent i not to appropriate, there can be many different collections of groups, having the features described in Proposition 4, that would compete for i. In this sense, there is generally no unique source of competitive advantage.

5. Applications

We now turn to a pair of applications in which the role of competition is central. The first application employs our framework and results to provide insights about a familiar theme in strategy—the connection between inimitability and competitive

[13] MacDonald and Ryall (2003a) provide a closely related, but more specific, proposition that enables these groups to be identified. In MacDonald and Ryall (2003b), we show how to employ the result to search for or evaluate new initiatives.

advantage. Competition is important in this example because the possibility of imitation is thought to influence value appropriation by stimulating competition. This application requires little structure beyond the coalitional game framework set out above. However, many applications have more structure that can usefully be included in the model to draw more specific conclusions. To illustrate how such structure can be used, and the kind of conclusions that emerge, we develop a second application, a model of innovation. In this application, competition among those who might use an innovation affects how much value the innovator can appropriate.[14]

5.1. Does Inimitability Yield Competitive Advantage?

That value appropriation is intimately related to ownership of value-creating resources that cannot easily be replicated by others is a widely accepted idea in strategy. For example, according to Coulter (1998), "If competitors can copy (imitate) each other, then a sustainable competitive advantage can't be developed and above-average profits can't be earned." Also, the mechanism through which inimitability is to operate is its impact on competition; see, e.g., Collis and Montgomery (1998, p. 32): "Inimitability is at the heart of value creation because it limits competition." Because our approach is designed to reveal the way competition influences value appropriation, we now devote some attention to imitation and its impact on competition and competitive advantage.

The first step is to state clearly what "imitation" means in the context of a strategic interaction. Of the many possibilities, there are two that appear to capture the flavor of familiar examples. The first definition describes imitation as embodying two features—an ability to produce a product that all purchasers agree is equivalent to the imitated product and also an ability to expand firm production and delivery activities so that an imitator can compete for all the customers in the market. The latter implies that there are no diseconomies of scale, scarce management talent, etc., that might limit the impact of having an essentially identical product. This definition of imitation, which we will call *unlimited product imitation*, is similar to the Bertrand competition familiar from industrial organization. It allows great scope for imitation to impact competitive advantage because it not only embodies the notion of similarity of products, but also maximizes its competitive impact by allowing an imitating firm to compete for all customers. In this sense, unlimited product imitation is an amalgam of imitative capability and other features of firms' technologies.

Unlimited product imitation can be described in the context of a strategic interaction by specifying that (i) the set of agents, N, consists of a set of customers, N_C, and a set of at least two firms, N_F (i.e., $N = N_C \cup N_F$), and (ii) if customers have access to one (or more) firm's product, then because the products are imitations of one another, no extra value is created by giving them access to another firm's product.[15] Formally, unlimited product imitation exists if, for any group G including all the customers (i.e., $N_C \subset G$) and at least one firm (i.e., $G \cap N_F \neq \varnothing$), we have $v_G = V$. Unlimited product imitation impacts value appropriation because it influences how firms compete for customers' participation. That is, if the distribution of value allows some firm to appropriate too much, any other firm can attract its customers by offering to appropriate less, leaving more to be appropriated by customers.

Because any firm can serve all the customers in the market, and customers value all products equally, it follows that each firm's marginal product is zero; the loss of any one firm does not harm value creation at all. Thus, Proposition 1—the necessity of positive marginal product for competitive advantage—delivers our first result on imitation.

Proposition 5. *Given a strategic interaction, (N, v), with unlimited product imitation, no firm has competitive advantage. That is, if*

1. *$N = N_C \cup N_F$, where $N_C \neq \varnothing$ and N_F has at least two elements; and*
2. *for all G such that $N_C \subset G$ and $G \cap N_F \neq \varnothing$, we have $v_G = V$;*

then $i \in N_F$ implies $\pi_i^{\min} = \pi_i^{\max} = 0$.

Unlimited product imitation is a very strong version of imitation in that it goes beyond the idea that customers see firms' products as equivalent by also making a set of implicit assumptions about firm technology and organization. As Proposition 5 shows, imitative capability, together with the absence of technological or organization factors that might limit firm growth, wipes out competitive advantage. However, the fact that these size-limiting features are rarely absent raises the question of whether imitative capability alone is really a threat to competitive advantage.

Our second definition, which we call *capability imitation*, is also a very strong definition of imitation. It differs from unlimited product imitation in that it distinguishes the capability to replicate another firm's product from the ability to expand output. Capability imitation arises when the value created by adding one

[14] In both cases, our model has a lot to say. However, presenting this material in detail is beyond the scope of this paper. Thus, we will stick to the simple setups and results that can be stated and explained concisely.

[15] For simplicity, we assume all firms are imitators. All that is required for our results is that there are at least two imitators.

firm to *any* group (consisting of consumers and possibly some other firms) is the same as the value that is created by adding any other firm. Thus, each firm has the capability to contribute exactly what any other firm can contribute in absolutely *every* situation. This is what we mean by a "strong" version of imitation. Formally, capability imitation exists if for every pair of firms i and j, and every group G including neither i nor j, we have $v_{G_{+i}} = v_{G_{+j}}$. With capability imitation, any firm has to deal with the possibility that if it appropriates too much, there is another firm which can successfully replace it.

Proposition 6. *Given a strategic interaction, (N, v), with capability imitation, firms may have competitive advantage, and all have the same value appropriation possibilities; i.e., if*

1. *$i \in N_F$ and $j \in N_F$; and*
2. *for any G not including i or j, $v_{G_{+i}} = v_{G_{+j}}$;*

then $\pi_i^{\min} = \pi_j^{\min} \geq 0$.

Capability imitation restricts how value can be distributed—$\pi_i^{\min}$ is the same for all firms—but it generally does not preclude competitive advantage. That is, the ability to imitate generally does not destroy a firm's being assured of value appropriation. For capability imitation to preclude competitive advantage, the strategic interaction must have some other feature—e.g., no diminishing returns, as in unlimited product imitation—that amplifies the impact of the competition for customers that imitation generates.

It is difficult to think of a realistic definition of imitative ability that is stronger than capability imitation. (Recall that unlimited product imitation is actually a definition of both imitative capability and other features of a firm's technology and organization.) Even so, capability imitation generally does not threaten competitive advantage. The reason is quite intuitive. As emphasized by Chen (1996), for imitation to have an impact, agents must have more than the ability to imitate—they must also have the motivation to do so.

To see the idea, imagine a monopolist who has capacity to produce at most two units of a product. Assume one unit can be produced for free and a second for \$1 (increasing marginal cost). There are two customers who each desire one unit of the product. One values a unit of the product at \$3 and the other at \$2. In this case, $V = 4$: \$5 of value to consumers net of \$1 of production cost. It is easy to show that the monopolist must appropriate at least \$1. An FSD resulting in this outcome distributes \$2 to the buyer who values the good most, \$1 to the other buyer, and \$1 to the monopolist. If the monopolist were to appropriate less, one of the customers and the monopolist could do better by acting on their own, reducing average production cost, and splitting the savings.

Now suppose the strategic interaction is exactly the same, except that the monopolist and each consumer have been "cloned." This implies capability imitation, so that as far as buyers are concerned, firms can be interchanged with no loss or gain in value. Despite the ability to imitate, neither firm has anything to gain by trying to compete for the other firm's customers. To see this, consider an FSD in which each firm appropriates \$1, the customers who value the product at \$3 appropriate \$2, and the other customers appropriate \$1. (Equivalently, each firm produces to capacity, and each customer purchases one unit of the good for \$1.) Suppose one firm considers acting on its own with only the pair of customers who value the product most, i.e., at \$3. This alternative generates \$5 in value that the three might share. However, the FSD is already distributing \$5 to this group, so this alternative offers no improvement. Thus, despite firms having all the imitative capability one can imagine, production capacity is too limited to allow imitation to wipe out competitive advantage. Firms own the "scarce factor," capacity, and so have competitive advantage despite their activities being imitable.[16]

5.2. Do Innovators Have Competitive Advantage?

A key issue facing a firm that considers investing in innovative activities is: How much of the incremental value created by the innovation can the firm appropriate? A common intuition is that if the innovation is unique and valuable, and there is competition among other firms or customers to use it, then the innovator ought to be able to appropriate some, maybe all, of the created value. With competition being a central element of our approach, we can provide some insight into whether/how this notion works.

Specifically, consider an innovator, I, who has developed and patented a new process or technology that can lower costs for any firm in some industry. Suppose, as is common in process innovation, that I cannot use the innovation himself; thus, I is contemplating licensing firms to use the innovation. To how many firms should it license? What kind of fees might it be able to extract? (In this setting, competitive advantage is simply the guarantee of a positive license fee.) To answer these questions, the rest of the strategic opportunity—i.e., the list of agents, how much value is created with and without the innovation, and so on—must be specified.

There are m ($m > 1$) firms in the industry, labeled F_i. For simplicity, firms have identical marginal cost, c, and fixed capacity, k. There are b buyers, B_i, who are

[16] This example suggests that the situation might be far different if there was a third firm, or free entry, or firms had more capacity, or there were more customers, etc. This is correct, and in each case our framework provides a precise answer to whether and how imitability precludes competitive advantage.

identical, seek to purchase one unit of the industry's product, and value a unit at v, where $v > c$.

How does the innovation work? Assume it lowers the marginal cost of any firm using the new process to γc, where $0 < \gamma < 1$. Observe that we have imposed an important feature of process innovation: One firm's using a process does not preclude another from doing so. It may be that I chooses to license to a single firm or to some subset of firms, but there is nothing about the innovation that forces I to exclude any firm from using the innovation. This will turn out to be important.

To focus on competition to use the innovation, assume buyers are abundant in comparison to capacity: $b > mk$. Because limited capacity means some buyer must go without the product, no value is lost if any individual buyer is removed from the strategic interaction. Thus, every buyer has zero marginal product and therefore, via Proposition 1, is guaranteed to appropriate 0. So, from now on we simply ignore the buyers and concentrate on whether competition among the m firms generates competitive advantage for I.

To determine whether I has competitive advantage, it is useful to begin by calculating the incremental value generated by the innovation, i.e., I's marginal product. The maximum value that can be created without the innovation is $(v-c)mk$. How much value is created by the innovation depends on how many firms use it. Suppose the innovation is licensed to a subset of the firms, numbering $m_I < m$. Because each firm is operating at capacity, total value created is $m_I(v-\gamma c)k+(m-m_I)(v-c)k$. Note that $\gamma < 1$ implies that total value created rises by $(1-\gamma)ck > 0$ if the technology is licensed to one more firm. This means, that no matter how value is distributed with m_I firms using the new process, by allowing one more firm to do so, the value available for appropriation by I and every firm is increased. Thus, there can be no FSD in which any firm goes without the new process.[17] The value created when the innovation is in use is, therefore, $m(v-\gamma c)k$ and I's marginal product is $m(1-\gamma)ck > 0$. Therefore, according to Proposition 1, I's having competitive advantage is a possibility.[18]

Each firm other than I contributes $(v-\gamma c)k$ by producing; so, this is F_i's marginal product. The value available to distribute, $m(v-\gamma c)k$, is exactly the sum of the firms' marginal products. Thus, I's minimum residual (i.e., value to distribute less the sum of the firms' marginal products) is zero. Recalling Proposition 2, the sufficient (but not necessary) condition for I to have competitive advantage fails. This situation is one in which determining whether I has competitive advantage requires more work (i.e., calculating I-minimum total value, directly checking whether every FSD results in I appropriating, or finding an FSD in which I fails to appropriate).

Consider a distribution of value in which I appropriates 0 (i.e., the license fee is 0) and each firm appropriates its marginal product. As just discussed, this distribution of value distributes exactly the value available to be distributed, and so is feasible. It is also stable. That is, for I to try to undermine this distribution of value, it must come up with an alternative that I and some subset of firms can act on that will make I and the subset of firms better-off. However, because each firm is operating at capacity and already appropriating all the value from its operations, this is not possible. In the end, I's having a unique, valuable innovation and multiple firms competing for it does not assure appropriation and therefore does not yield competitive advantage.

This result might seem surprising at first. Why can I not appropriate by somehow making the firms compete for the innovation? The reason is simply the important feature of process innovation noted earlier: The innovation's being licensed to one firm does not preclude its being licensed to any other firm. In effect then, the situation is as if I and each F_i is in a separate, two-agent pure bargaining interaction in which the value produced is $(v-\gamma c)k$. In situations of this kind, any distribution of value, including I appropriating 0, is stable.

If this logic is correct, then why would anyone devote resources to innovating? On one hand, I's appropriating positive value is not assured. On the other, an argument similar to the one showing I might fail to appropriate shows that I might appropriate his marginal product, $m(1-\gamma)ck$. Harking back to the discussion of the pure bargaining example in §2, our point is not that the innovator should expect to appropriate either 0 or his marginal product. Instead, whatever I ends up appropriating, it will *not*, contrary to the familiar intuition, be determined by the forces of competition (except insofar as appropriation cannot be negative or more than I's marginal product). Indeed, the situation here is quite the opposite. A firm contemplating investing in process innovation should anticipate that forces other than competition—all the activities commonly lumped together and called "bargaining"—will turn out to be critical in determining how much it appropriates. Focusing attention on stimulating competition among the potential users

[17] At first, this outcome may seem somewhat unintuitive. It is natural to think of restricting use of the innovation as a way for I to appropriate more from those who use it. In our framework, which supposes that agents have a lot of freedom in the way they arrange their business dealings, agents will find their way around any such value-reducing restriction.

[18] A small technical point to note is that because F_i can always produce without the new process, and so earn $(v-c)k$, this example is not normalized. This has no impact on our conclusions.

of the new process, rather than how one is going to bargain with them, is a serious mistake in situations of this kind.

6. Final Thoughts and Caveats

We have provided a formal, general way to analyze how competition impacts an agent's appropriation possibilities, but like any formal framework, ours has subtleties and limitations that must be appreciated when applying it. One limitation of this paper is that we have focused on the minimum level of appropriation consistent with agents' alternatives, i.e., $\pi_i^{\min}$. This simplifies, and is of interest because any agent having competitive advantage in the way we have defined it—i.e., positive assured appropriation—would gladly participate in the value creation opportunity. However, more generally, the maximum appropriation consistent with competition, i.e., $\pi_i^{\max}$, is also highly relevant (and amenable to analysis analogous to that in this paper). The same can be said for the bargaining process that ultimately determines exactly what, in the interval bounded by the minimum and maximum, an individual finally appropriates. In work currently underway, as well as in MacDonald and Ryall (2003b), we employ Brandenburger and Stuart's (2003) result on representation of preferences over intervals to include both $\pi_i^{\max}$ and bargaining. Briefly, agent i behaves as if the outcome of bargaining is expected to be

$$\alpha\pi_i^{\max} + (1-\alpha)\pi_i^{\min},$$

and evaluates whether to participate in terms of this expression. The parameter α, $0 \leq \alpha \leq 1$, can be interpreted as "bargaining confidence." Thus, our current focus on $\pi_i^{\min}$ is especially appropriate when agent i believes his bargaining prospects are poor.

We have also assumed that agents are free to act on their alternatives. That is, if they have some alternative that they see as preferable to some contemplated distribution of value, then they can act on this alternative. One might wonder whether, e.g., if Intel's customers think its microprocessors are too expensive, they really will act on some alternative with Advanced Micro Devices (AMD). Persuading AMD to do this might be very costly, depending on the nature of required adjustments to AMD's production. In our framework, considerations of this sort are part of the specification of v. That is, if group G's acting on some alternative is costly, then v_G must be net of these costs; likewise for alternatives that are expensive because they might violate laws or regulations. Finally, the coalitional game framework, especially the specification of v, can be used to address questions like: When does the law of one price follow from competitive behavior rather than being an assumed behavior?[19] The coalitional framework is very general, and fully capable of including considerations of this nature.

In terms of limitations, we showed that an agent must appropriate a positive amount when his failure to do so is inconsistent with feasibility and stability. In so doing, we assumed that there is at least one way in which value can be feasibly and stably distributed. Conditions on (N, v) that are both necessary and sufficient for this assumption to be valid are well known; see, e.g., Osborne and Rubinstein (1994). These conditions, however, do restrict the strategic interactions that can be studied using the coalitional approach. For example, every strategic interaction in which $V > 0$, but every agent has a zero marginal product, fails to satisfy these conditions.[20] Luckily, it appears that many situations of interest fall inside the scope of our analysis. Still, little is known about how to proceed otherwise. Second, we have assumed that agents understand the nature of the strategic interaction; i.e., they know N and v. Uncertainty about v is not problematic, at least in the sense that v can simply be viewed as an expected value. However, that agents have a common belief about v is important for that interpretation. Third, we interpret v as the value of activities that extend into the future and, to arrive at conclusions that are not too model specific, we say little about how the future, uncertainties, etc., are to be included. However, especially in applications, the value of the model's conclusions may be enhanced considerably by incorporating these details; see MacDonald and Ryall (2003b). Finally, we have assumed that whatever one agent values at \$1 is valued at \$1 by any other agent. When uncertainty is important so that risk aversion might differ across agents, or when the value creation activities are spread over time so that differences in discount factors might differ, this assumption will have to be relaxed; see, e.g., the discussion of coalitional games without transferable payoff in Osborne and Rubinstein (1994). For strategy applications, familiar corporate finance arguments about shareholders' ability to diversify suggest that the assumption that all agents see value in the same way is reasonable.

An electronic companion to this paper is available at http://mansci.pubs.informs.org/ecompanion.html.

Acknowledgments

The authors thank Adam Brandenburger, Daniel Levinthal, Patrick Moreton, Jackson Nickerson, Gus Stuart, Joe Ostroy, the associate editor, two referees, and participants at the

[19] See, e.g., Moulin's (1995) discussion of the core and perfect competition.

[20] This is an example of the $mr_i > mp_i$ case mentioned in Footnote 10.

Harvard, Kellogg School of Management, New York University, Toronto, and Yale strategy seminars, in addition to those at the 2001 Strategy Research Forum at Northwestern University, for thoughtful comments.

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