Leveraging the Customer Base: Creating Competitive Advantage Through Knowledge Management

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Professional services firms (e.g., consultants, accounting firms, or advertising agencies) generate and sell business solutions to their customers. In doing so, they can leverage the cumulative experience gained from serving their customer base to either reduce their variable costs or increase the quality of their products/services. In other words, their "production technology" exhibits some form of increasing returns to scale. Growth and globalization, coupled with recent advances in information technology, have led many of these firms to introduce sophisticated knowledge management (KM) systems in order to create sustainable competitive advantage. In this paper, the authors analyze how KM is likely to affect competition among such professional services firms. In particular, they first explore what type (supply-side versus demand-side) of economies of scale are likely to be exploited in KM systems. In the former case, KM's role is to reduce the operating costs of the firm, while in the latter case, its role is to create added value to customers by significantly increasing product quality. Second, the authors analyze the competitive dynamics and market structure that emerge as a result of firms competing with KM systems. The results shed light on the current literature exploring the deployment of KM systems by suggesting that in a competitive setting, when firms' ability to leverage their customer base is high, KM should lead to quality improvement rather than cost reductions. In a dynamic setting, it is also shown that when firms use their KM system to improve product quality, higher ability to leverage the customer base may actually hurt profits and lead to industry shakeout. Beyond normative insights, the results also support a number of recent market trends in management consulting, including the increased emphasis on knowledge-creating activities in modern KM systems, the wave of mergers between consulting firms, and the recent emergence of "retail consulting" services.
(*Increasing Returns to Scale; Network Externalities; Knowledge Management; Competition*)

1. Introduction

It is hard to open today's *Wall Street Journal, Business Week*, or other popular business magazines and not read or hear about "knowledge management" (KM). There are dozens of Web sites and special publications devoted to KM, with hundreds of academic papers and several books published on the topic.

Corporations are investing heavily in building KM systems, and professional services firms (e.g., management consultants, accounting firms, or advertising agencies) are no exception. In a survey we conducted with the top 40 management consultants in the United States, over 90% of the firms that responded (20 out of 22) claimed to have a KM system up and running by

the end of 1999. Similarly, the majority of these firms (14 out of 22) identified KM as a key success factor for their business. For instance, Ernst & Young, which has identified KM as a major component of its corporate strategy, claims to have spent over $500 million on KM-related information technology (IT), dedicated "knowledge centers," and people. Other firms quote similar figures (Hansen et al. 1999, p. 114).[1] In fact, many attribute the birth of KM to this sector, which was the first to explore the implementation of formal KM systems.

What is the reason for the sudden emergence of KM in the professional services industry? Growth and globalization are part of the answer.[2] Growth and globalization have created both the need and the opportunity to formally harness the vast and dispersed experience of the professional service firm. Another important driver behind the emergence of KM is recent developments in IT (especially network technologies and database management). IT has provided new tools to build the physical infrastructure of KM systems. Although organizations have always had ways to integrate their members' individual experiences, IT provides a significant increase in the ability to execute this process.

What is the role of KM in professional services firms? Professional services firms generate and sell business solutions to their customers. In general, business solutions are not created from scratch, but rather, they are generated using the collective experience of the firm (see the recent survey of *The Economist*,

March 22, 1997). KM is the set of business processes that capture and provide access to this collective experience. In economic terms, KM represents the "production technology" for such firms whose core product is business knowledge itself. As this knowledge is generated through customer contacts or sales (i.e., it directly results from the firm's past and present experience), the "KM technology" exhibits increasing returns to scale, whereby the firm benefits from having a larger customer base. Using KM, the professional service firm can leverage its customer base in several ways. On the one hand, the KM system can be used to significantly reduce the firm's variable costs by increasing efficiency. KM processes aimed primarily at cost reduction (i.e., supply-side economies of scale), make it easier for professionals to *locate* previously generated solutions and *adapt* these to their client's problem. This can be achieved, for example, by developing an electronic document system that extracts and stores critical features of existing business solutions in a way that allows fast and effective use by other teams. Such electronic repositories are usually managed centrally by dedicated personnel, who are primarily responsible for rigorous quality control (making sure that entries are substantive, accompanied by important contextual details, properly classified, and entered in a common format),[3] but also rely heavily on setting up the right incentives so that individual consultants contribute their input to the system promptly and meaningfully. Efficiency can also be achieved by facilitating communication between people within the firm so that a consultant spends less time and effort tracking down relevant colleagues. From an institutional perspective, this typically involves better communication technology (email, directories, etc.). The ongoing maintenance of the "experts directory" at Booz, Allen & Hamilton is an example. Common to the uses of KM described above is that the results of an assignment can (at least partially) be re-used by another team, which then generates a similar business solution in less time, and/or requiring fewer consultants and company resources.

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[1] Investments in KM systems include computer equipment and communication networks. However, most of the expenditure comes from the ongoing fixed cost of the personnel running the system or the cost of lost billing time as a result of consultants contributing to the system. Ernst & Young's Center for Business Knowledge (CBK), for instance, employs over 100 professionals, and is only one of the three "knowledge centers" explicitly dedicated to KM.

[2] In the last few decades, the professional services industry has experienced a spectacular and systematic growth. Management consulting, for example, grew at an average of 16%–18% per year over the last 15–20 years (see, for example, *Consulting News'* 1996 survey). Once composed of only a handful of small firms, today this industry generates over $40 billion, with most firms having a global presence. Similar trends and growth figures are reported for marketing agencies by *Advertising Age* in its "ten-year gross income and volume review" (see ⟨www.adage.com⟩).

[3] For instance, Price Waterhouse has set up four knowledge centers around the world to perform these exact functions for its electronic repository, *Knowledge View.*

On the other hand, a KM system can also generate demand-side economies of scale through the creation of new, deeper knowledge that enhances the quality of the services/products offered by the firm. This is achieved by a better understanding of the business environment through the *analysis* of consultants' experiences, which in turn can lead to qualitatively better business solutions and more favorable evaluations of the firm by its clients, in other words, network externalities. In such a system, the emphasis is on the *synthesis* of the insights gained from individual assignments rather than on their mapping and categorization for more efficient search, adaptation, and re-use. The output of this activity is more conceptual knowledge and/or general analytic frameworks to generate business solutions, in this respect, similar to the research conducted at academic institutions. Depending on their business context, consulting firms use a variety of institutions to create new knowledge, which can then be drawn on to enrich the quality of service offered to clients. Often, new knowledge is created in specialized knowledge centers whose employees are specialists or researchers rather than field consultants. E&Y's Center for Business Innovation (CBI) or McKinsey's Global Institute are such "think tanks" where academic leading edge thinking is bridged with practice. New knowledge may also be created in so-called "communities of practice," "knowledge teams," or discussion forums that usually have a small core of professionals synthesizing the insights from consulting assignments in a specific industry or service area. Samples from the knowledge-creating effort of these institutions are often published in reports, books, or white papers (e.g., *The McKinsey Quarterly*) or presented in conferences.

The existence of these two objectives in leveraging collective experience constitutes a central finding of a recent, comprehensive study of best KM practices by Skyrme and Amidon (1997). The study reveals that "two main thrusts characterize the focus of the knowledge management agenda." The first is the "dissemination and application of knowledge that exists somewhere in the organization," which in the reported case studies of consulting companies results in significant time/personnel savings for future projects (e.g., p. 246). The second is "the creation of new knowledge and its rapid conversion into new and improved products, services and processes." While the two thrusts of KM are documented to pose widely different implementation, deployment, and ongoing maintenance challenges, it is their different impact on firms' capabilities, namely the lowering of production costs and the enhancing of product quality, that bears strategic significance. As such, the focus firms place on each form of increasing returns directly affects their competitive standing.

The first goal of the study reported here is to explore how profit-seeking firms choose the degree of emphasis to be placed on these two different KM objectives.[4] Given that the processes required by these two objectives represent different (and costly) implementations, and given that they affect profits differently, the decision firms face is how to optimally allocate resources between them. Formally, our model investigates what happens if competing firms, by choosing the appropriate design of their KM systems, can endogenously influence the *type* of scale economies they subsequently face. In particular, we ask how the ability to leverage scale economies and firm-specific asymmetries will affect this design decision. We generally find that, *in a competitive setting*, when the ability to exploit economies of scale is high enough, firms are better off shifting emphasis to systems generating higher quality service to customers rather than focusing on cost reduction. This is in sharp contrast to a monopolist, which is always better off focusing on cost reductions. The main intuition

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[4] In practice, virtually all KM systems incorporate a number of processes, some of which predominantly accomplish cost reduction, while others facilitate knowledge creation to improve quality of service. For example, Booz, Allen & Hamilton's KM system, *Knowledge On-Line* (KOL), has two main features. The first captures, classifies, and structures current "best practices" for the re-use of existing knowledge. The second synthesizes ideas from expert partners in a nonclient-specific form (called "nuggets" and "gems") to assist in developing "next practices." Similarly, at E&Y, in addition to the CBI described earlier as focusing on new creative analysis, the company has also developed *Knowledge Web*, an Intranet that provides all consultants in the firm effective access to previous client work and best practices.

behind these findings is that, in our context, quality improvements are achieved through the generation of indirect network externalities. Therefore, cost reductions have a stronger first-order effect on profits than quality improvements, as the latter are only realized through the fulfillment of customer expectations. Hence, the monopolist, which does not have to compete for demand, always chooses to reduce variable costs. However, under competition, the choice of design also has a strategic effect on profits because now firms compete for demand. When the incremental benefit of the customer base is relatively high, this strategic effect makes it more profitable for firms to focus on quality enhancement to generate favorable customer expectations.

The second objective of this study is to investigate strategic behavior when firms compete with KM systems geared predominantly to improving product/service quality. Beyond learning about the incentives of firms to leverage their customer bases, we also hope to shed light on a number of trends in the consulting industry. For example, we find that when scale economies are large enough, initial differences in the size of the firms' customer base tend to increase over time. This means that firms have strong incentives to rapidly grow the size of the customer base from which to draw business experience. This finding is consistent with the wave of mergers and acquisitions in the consulting industry, and is in sharp contrast to the past when the number of firms would often increase through spin-offs. A recent example is Cap Gemini's announcement to acquire E&Y for over $11 billion (CNN, February 29, 2000). Other examples among former Big-6 firms include Price Waterhouse's merger with Coopers and Lybrand, and Andersen Consulting's former plans to merge with Deloitte and Touche. The mergers of AT Kearny with EDS, Foster with Mercer and Alexander, and Alexander with the Aon Consulting Group further support this trend. In a dynamic two-period model, we also find that firms, anticipating the existence of effective KM systems, will aggressively build a larger customer base at lower first-period prices. Again, we find support for this finding in the recent emergence of what we call "retail consulting," i.e., firms' tendency to introduce inexpensive consulting services. E&Y's "Ernie"

product is one typical example, but other firms have also announced the introduction of similar low-cost services to their client base.

The paper is organized as follows. In the next section, we relate our work to the relevant literature. Section 3 begins with the development of a formal model to study the endogenous choice between different forms of scale economies. Based on the conclusions of this analysis, we modify the model to study how competition evolves in a world where firms use KM to provide higher quality service to customers. Throughout the paper, care is taken to relate the analytical findings to real-life market outcomes and highlight their managerial implications. The paper ends with concluding remarks.

2. Related Literature

Our work is related to four broad literature streams. First, it is related to the vast literature on KM. It borrows its conceptual foundations from Hargadon and Sutton (1996) and Hargadon (1998), who see the professional service firm as a "knowledge broker" between clients. The basic idea is that because of its central position, the broker can identify and transfer solutions (or experience) between relatively isolated sectors of the economy (e.g., across different industries, countries, etc.). In this context, much of the subsequent research has explored organizational aspects of KM, uncovering different internal mechanisms through which knowledge is shared and created within the firm.[5] That the primary objective of KM in professional services firms is to generate

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[5] For example, Hansen et al. (1999) discuss differences in KM practices based on whether the consultant's experience is captured in a document format ("people-to-documents") or if it is transfered through personal contact ("person-to-person"). They argue that the emphasis on either implementation is affected by the type of consulting submarket the firm is in. Such submarkets differ in the nature of experience acquired and the type of solutions provided by the firm. In contrast, our paper looks at a particular submarket and examines KM role emphasis (i.e., cost reduction vs. quality enhancement) in the context of ability to generate increasing returns to scale and competition. Differences between such submarkets can be accounted for in our model by varying certain model parameters (e.g., setting upper/lower bounds on the ability to achieve either form of increasing returns).

increasing returns to scales of different forms has been recently suggested by Teece (1998, p. 60). Moreover, it is argued that while ideally firms would like to benefit from both forms, in practice, KM that achieves greater "productivity" typically implies less "creativity." This distinction between the different KM objectives is consistent with the findings of Skyrme and Amidon (1997). Since economies of scale have important implications for competition, and because the KM system design problem is clearly influenced by implementation trade-offs, we believe that competition plays a key role in guiding firms on which specific KM system design to implement.[6]

Second, the paper is directly based on prior research on production technologies exhibiting increasing returns to scale. Relevant to our context, increasing returns due to demand-side effects have largely been covered by the literature on network externalities (Katz and Shapiro 1985, Farrell and Saloner 1986, Economides 1996a). The basic idea is that consumers benefit from other consumers joining a particular firm's customer base. As such, a large customer base might represent sustainable competitive advantage for the firm. In the context of the professional services industry, if firms choose to improve their product quality through the integration of client assignments, they essentially generate *indirect* network externalities. With such a KM system, a larger customer base represents deeper understanding of the business context and, therefore, will result in better business solutions. Consequently, clients benefit from joining firms with larger customer bases. The network externality is indirect because clients only benefit from the presence of other clients in the customer base through the knowledge-creating activity of the knowledge broker. The second research area, which addresses supply-side economies of scale, is the literature on learning by doing (e.g., Spence 1981, Tirole 1988). Here the idea is that larger output or

production can lead to smaller marginal costs, which again can result in long-run competitive advantage. While both forms of increasing returns to scale might lead to similar outcomes (e.g., pioneering advantage, winner-take-all scenarios, or path-dependence), there are important differences. In particular, in contrast to supply-side economies of scale, under network externalities customer expectations play a key role in defining the ultimate competitive outcome (see Katz and Shapiro 1985, Shapiro and Varian 1999). Our paper integrates these two literature streams by *endogenizing* the extent to which firms might benefit from either form of increasing returns. In our framework, by choosing the appropriate design of the KM system, a firm is able to influence the weight given to processes generating indirect network externalities (thereby improving service quality) or processes facilitating learning by doing (thereby reducing production costs). We believe that professional services firms trying to implement expensive KM systems for strategic reasons face exactly this problem. Our paper explores the implications of firms making such choices in a competitive setting.[7]

Third, our paper is related to the literature on product versus process innovation. Bonanno and Haworth (1998), for example, look at the choice between these innovations by one of two competitors, with only one type of innovation implementable in any given scenario. They examine how differences in competition intensity and firm-specific asymmetries (in product quality or production costs) are likely to lead to different prescriptions for directing innovative effort. We ask similar questions to the extent that firms' choice of KM system design will either affect their cost structure or customers' valuation of their services. However, in our framework *both* firms simultaneously choose from a continuum of alternative KM system designs. Another related paper is by Rosenkranz (1996), which studies firms' costly investments in the

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[6] In the context of investment in sophisticated IT systems, a number of consultants have recently recognized that the biggest challenge CEOs face when making implementation decisions is how to manage IT for building competitive advantage. Furthermore, two primary objectives of IT systems are identified, "cost" and "value," each having very different implementation characteristics (see Callahan and Nemec 1999).

[7] High-tech companies producing physical products (hardware and software) have been shown to face increasing returns to scale (Arthur 1996). In fact, the existing literature assumes that the magnitude of network externalities is exogenous in any given industry. In contrast, in the professional services sector, for any given customer base, more network benefit can be generated to customers by investing in the synthesis of the firm's experience.

two types of innovations. In her model, firms can innovate along either dimension independently, and she explores the effects of firms' coordination on R&D effort and exogenously increasing basic demand on equilibrium outcomes. In the model proposed here, the cost of the KM system is assumed fixed (and sunk), and the analysis centers on the interdependent allocation between product vs. process improvements. More important, unlike both of the above papers, which assume constant returns to scale, our context is characterized by a competitive environment with increasing returns to scale, as in our case product quality and/or variable costs are a function of firms' outputs. Furthermore, firms' ability to exploit returns to scale is the main driver of our results.

Finally, our work is also related to a number of papers in the marketing literature. Villas-Boas (1994) examines the role of an (advertising) agency in leaking information between its competing clients. The paper shows that a common agency (e.g., a consulting firm) might lead to positive or negative learning effects for its clients, depending on industry characteristics. In contrast to his monopoly setting, our paper looks at competition between such agencies and assumes positive learning between nonstrategic customers. This assumption is justified in our case, as clients of consulting firms are either noncompetitors, or in the opposite case, are ensured that information leakage is not detrimental to their business.[8] Economies of scale and scope have also been addressed in Silk and Berndt (1993) in the context of advertising agencies. In their empirical paper, however, these effects are solely a result of supply-side considerations. In contrast, we assume that by choosing an appropriate KM system, firms can affect the extent to which they benefit from different types of economies of scale. Finally, competition between firms in markets with network externalities has also been studied by Padmanabhan et al. (1997). In that paper, firms are exogenously endowed with network externalities and their concern is how to credibly signal high network externalities to consumers. In contrast,

in our model, network externalities are endogenous and there is no asymmetric information.

3. The Model

3.1. Choosing the Design of the KM System
We start by asking the question: What emphasis would professional services firms choose to place on the two different forms of increasing returns to scale? For this purpose, we study a duopoly with two firms selling business solutions to their clients.[9] We start by assuming that firms are ex-ante symmetric and later explore the effect of asymmetries. In the absence of KM, firms face a standard linear (inverse) demand,

$$p = 1 - y_1 - y_2,$$

where y_i is the output of firm i ($i = 1, 2$). We assume that both firms invest in KM to leverage their customer base, which, depending on the firms' choice of design, will affect their demand or unit production cost. In the presence of KM processes exploiting demand-side economies of scale, each client essentially benefits from other clients who will choose the same firm, i.e., there are indirect network externalities. We assume that clients cannot costlessly switch between firms in the short run, hence they need to form expectations about the size of each firm's customer base.[10] As such, after the choice of KM system design by firms, which becomes common knowledge, consumers form expectations about network sizes, and then firms choose output taking these expectations as given. More precisely, if consumers expect firm i to have a network of size y_i^e, then they assume that the corresponding added benefit to them is $f_i(y_i^e)$. Economies of scale means that $\partial f_i / \partial y_i^e > 0$. Thus, given its KM system, firm i faces the following inverse linear demand:

$$p_i = 1 + f_i(y_i^e) - y_1 - y_2. \tag{1}$$

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[8] Bain and Co., for example, refuses to consult a prospective client who directly competes with an existing customer. Other consulting firms also guarantee "iron walls" between their competing clients.

[9] Throughout the paper, we study a duopoly. None of our substantive results are driven by this restriction.

[10] In reality, clients choose a professional services firm to form a relatively long-term business relationship. If consumers could costlessly switch from one firm to another, then expectations would not have a role. For a detailed discussion on when the time-scale of users' commitments matters for the expectations process, see Farrell and Katz (1998).

This demand structure differs from the standard linear demand above in that it incorporates indirect network externalities; the larger the customer base of the firm the higher the service quality each client receives.

The choice of KM system design may also lead to supply-side economies of scale. In other words, as the firm produces more output (has more clients) its marginal cost to generate business solutions decreases. We assume that this cost reduction is $g_i(y_i)$. As before, economies of scale means that $\partial g_i/\partial y_i > 0$. Thus, if the marginal cost without KM is assumed to be c, then in the presence of KM, firm i's marginal cost becomes

$$c_i = c - g_i(y_i). \tag{2}$$

Note that in contrast to quality improvements resulting from network effects, customers do not form expectations about this cost reduction. In essence, this means that clients form expectations about variables they can directly observe in the marketplace. In particular, consistent with the literature on learning by doing, we assume that clients do *not* form expectations about cost reductions for two reasons: (1) Internal costs are not transparent to clients—who are typically only confronted with "billing rates,"—and can more easily be hidden by firms; and (2) clients make their decisions based on expected surplus to them, hence, given firms' output choice, production costs are not relevant for determining demand.[11] Thus, a central feature of our model is that *through the design of their KM system, firms can influence the extent to which expectations play a role in their final demand.*

In designing their KM system, firms need to decide to what extent they want to benefit from network externalities vs. supply-side economies of scale. To model this choice, we assume that both have a common linear metric.[12] In other words, we assume that

the marginal value of each unit of output is α, where $0 \leq \alpha < 1$. In essence, α measures the effectiveness of the KM system or the marginal benefit of the customer base.[13] Thus, the potential gain from a client base of size y is αy. Given α, the design decision means that each firm can choose to allocate any portion β_i ($0 \leq \beta_L \leq \beta_i \leq \beta_H \leq 1$) of this "potential gain" to improve the quality of its service, while $(1-\beta_i)\alpha y$ is used to reduce the firm's variable cost. The parameters β_L, β_H reflect the inherent degree of freedom firms have to allocate resources to achieve either of the two KM objectives (see Footnote 5). When $\beta_L = 0$, $\beta_H = 1$, the firm is unrestricted in the degree of emphasis it can place on each form of increasing returns.

Firms play a two-stage game. In the first stage, they choose the design of the KM system (β_i), which becomes common knowledge. We assume that the fixed cost of implementing a KM system is the same irrespective of β_i, and without loss of generality, is taken to be 0. Next, clients form expectations about the size of the firms' customer bases, after which firms compete in the market by choosing output in a standard Cournot-type game, taking customer expectations as given.[14] Specifically, in the second stage, firms maximize the following profit function:

$$\begin{aligned}\pi_i &= (p_i - c_i)y_i \\ &= ([1 + \beta_i \alpha y_i^e - y_1 - y_2] \\ &\quad - [c - (1-\beta_i)\alpha y_i])y_i \quad i = 1, 2. \end{aligned} \tag{3}$$

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[11] If firms could commit to output levels or guarantee the number of clients they will ultimately serve, then expectations would not play a role under any KM system design choice (see the appendix of Katz and Shapiro 1985). We would like to thank the reviewers for asking us to clarify these points.

[12] While a priori it is not necessary that demand- and supply-side economies of scale have the same functional form, for simplicity and to concentrate on the *strategic effect* of the design decision, we

assume a common linear metric for both. Obviously, if the marginal return per unit of output is significantly larger with supply-side economies of scale, this would mitigate our results, as in this case, firms would have less incentive to invest in generating network benefits. However, the interesting research question to ask is what drives the choice of KM system design if the marginal return on both types of scale economies is roughly the same. For the same reason, we will assume no asymmetry in the fixed cost of implementing KM processes that generate either of the two forms of increasing returns.

[13] The constraint on α reflects the idea that there is overlap between clients in terms of learning. Technically, this constraint ensures that the profit functions are concave.

[14] Because either cost reduction or quality improvement generated by KM is output related, it is reasonable to assume that output is the relevant strategic variable. This second stage quantity game is similar to Katz and Shapiro (1985) or Economides (1996b).

We are looking for fulfilled expectations equilibria (see, e.g., Economides 1996a). To solve for such an equilibrium, differentiate each firm's profit function by its output, holding all else constant, and set these derivatives to 0. Thus, a best-response schedule for the two firms is given implicitly by

$$\begin{cases} 1 + \beta_1 \alpha y_1^e - \sum_{j=1}^{2} y_j - c + 2(1-\beta_1)\alpha y_1 - y_1 = 0 \\ 1 + \beta_2 \alpha y_2^e - \sum_{j=1}^{2} y_j - c + 2(1-\beta_2)\alpha y_2 - y_2 = 0. \end{cases} \quad (4)$$

In equilibrium, expectations have to be fulfilled so y_i^e is replaced by y_i, $i = (1, 2)$ in (4). Solving for y_i yields the equilibrium. Note that outputs should be nonnegative, hence $y_j = 0$ whenever $y_i \geq 1 - c$.

3.1.1. Monopoly. To set a benchmark, we first look at a monopolist. The following proposition shows that a monopolist is always better off building a KM system designed to reduce production costs.

PROPOSITION 1. *The monopolist maximizes profits by setting* $\beta = \beta_L$.

PROOF. Solving (4) when $y_2 = 0$ and setting $y^e = y$, the optimal profit as a function of β is

$$\pi_m^* = \frac{(1-c)^2(1-\alpha+\alpha\beta)}{(2-2\alpha+\alpha\beta)^2}.$$

It is easy to show that this expression decreases in β. □

This result is not surprising if one examines (4) under a monopoly. It is easy to see that the effect of decreasing β on marginal cost is greater by a factor of $\beta\alpha$ than the effect of increasing β on marginal revenue through network externalities. This makes it more beneficial for the monopolist to decrease costs rather than rely on network effects.

3.1.2. Competition Between Symmetric Firms. Next, we look at the design problem under competition. We start by assuming symmetric firms and relax this assumption in the next section. We will show that competing firms behave differently from a monopolist, *but only if firms' ability to leverage the customer base is high enough*. The following proposition summarizes the outcome under this scenario.

PROPOSITION 2. *If* $\alpha < 1/(2 - \beta_L)$, *the unique equilibrium is* (β_L, β_L). *If* $\alpha > 1/(2 - \beta_L)$, *then in any equilibrium* $\beta_1 = \beta_2 = \beta > \beta_L$. *In particular, if* $\alpha > 1/(2 - \beta_H)$, *then the unique equilibrium is* (β_H, β_H).

PROOF. See the appendix.

Proposition 2 says that in a competitive setting, as α (i.e., the incremental benefit of the customer base) increases, firms put more and more weight on designing KM systems aimed at increasing quality, thereby generating demand-side economies of scale. This is in sharp contrast to the monopolist who always focuses on cost reductions. The basic intuition behind this finding is that in our context, quality improvements are achieved through the generation of indirect network externalities. For the monopolist, cost reductions have a stronger first-order effect on profits than quality improvements, because the latter are only realized through the fulfillment of customer expectations. Hence the monopolist, which does not have to compete for demand, always chooses to reduce costs. However, competition introduces a strategic effect on profits because now a firm's demand also depends on the response of its rival to its choice of KM system design.[15] When the incremental benefit of the customer base is relatively high, this strategic effect makes it more profitable for firms to focus on quality enhancement, i.e., generate favorable customer expectations.

The finding in Proposition 2 is consistent with the increased emphasis on practices assisting knowledge-creating activities in modern KM systems within the consulting industry. These include, for example, further investment in think tanks, systematizing internal publication of newly developed concepts, and the recruitment of more ex-academics on "research-career" paths (Peters 1992, pp. 387–389; Bartlett 1996, p. 9). The result also provides insight with respect to the timing of this KM trend. It says that KM

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[15] In our model, the strategic effect refers to the change in profits expected to firm i as a result of firm j's reaction to an increase in β_i. Technically, when these functions are differentiable, this can be written as

$$\frac{\partial \pi_i}{\partial y_j} \frac{dy_j^*}{d\beta_i}$$

(see Tirole 1988, pp. 323–326).

is likely to be aimed at quality enhancement rather than cost reduction if the incremental benefit from a larger customer base is high enough. As discussed before, growth and globalization coupled with important advances in IT have resulted in a significant increase in firms' ability to exploit the customer base (high α) for the professional services sector. Therefore, it is not surprising that IT experts have recently argued for a reevaluation of the role IT plays in organizations, with a shift from practices merely improving the efficiency of ongoing operations observed in the 1980s to generating strategic benefit through value creation (Callahan and Nemec 1999).[16]

3.1.3. The Effect of Firm-Specific Asymmetries on Competitive KM Design.

In the previous section, we have assumed perfectly symmetric firms. Since in reality there may be large differences between firms in terms of perceived quality, reputation, or existing customer base, it is important to evaluate the effect of such asymmetries on the system design problem.

To do so, assume Firm 1 faces the following inverse demand:

$$p_1 = 1 + \gamma + \beta_1 \alpha y_1^e - y_1 - y_2, \tag{5}$$

while Firm 2's demand is identical to (1). Here, $1 - c > \gamma > 0$ is a firm-specific parameter that reflects, for example, the inherent advantage of Firm 1 in generating business solutions without KM: the higher quality of its professionals or its brand equity. The following proposition summarizes the outcome for asymmetric firms.

PROPOSITION 3. *If* $\alpha < \alpha_1 = (1 - \gamma/(1-c))/(2 - \beta_L)$, *then the unique equilibrium is* (β_L, β_L). *If* $\alpha_1 < \alpha < \alpha_2 = (2 - (1-c)/(1-c+\gamma))/(2 - \beta_L)$, *then* $\beta_1 = \beta_L$ *and Firm 2 is driven out of the market. If* $\alpha_2 < \alpha < \alpha_3 = (2 - (1-c)/(1-c+\gamma))/(2 - \beta_H)$, *then there is no equilibrium in pure strategies. Finally, if* $\alpha > \alpha_3$, *then* (β_H, β_H) *is the unique equilibrium.*

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[16] For example, they document a change in the strategic objective of IT at Capitol One, a financial services company, from merely allowing more efficient targeting of customers with existing products to that of assisting in the creation of new financial products and services.

PROOF. See the appendix.

Proposition 3 provides two important conclusions. First, it says that if the quality difference (i.e., γ) is small, then the design choice is similar in spirit to the symmetric case: For high values of α, firms tend to build KM systems generating extra value to customers, whereas for low levels of α, they tend to use KM for cost reduction. In the case when the quality difference between the two firms (γ) is moderate or large, the likely equilibrium is an asymmetric one, in which the high quality firm invests in cost reductions and drives the low quality firm out of the market. This result maps into the monopoly case analyzed in §3.1.1. The interesting insight we obtain here is that there is an interaction between α and γ over a certain range; as the ability to leverage the customer base (α) increases, a smaller quality difference (γ) is sufficient to produce the monopoly outcome.[17] As such, α can reinforce ex ante quality differences. This also suggests that when the quality gap between firms is substantial, the low quality firm should narrow this gap before attempting to rely on potential increasing returns through KM.

3.2. Competition with KM Based on Network Externalities

In the previous section, we examined what KM system design competing firms would choose: one that focuses on decreasing the firm's costs by making it more efficient in delivering business solutions, or one that is likely to generate higher quality service to customers. We found that the answer depends on the incremental benefit of the firms' customer base. The higher this benefit, the more firms tend to build KM systems focused predominantly on enhancing the quality of the service they provide to customers.

Rather than looking at the design problem, this section examines the strategic interaction between firms competing with KM systems geared at quality enhancing knowledge creation. In other words, in this section, we assume that KM results entirely in demand-side economies of scale through network effects, and ask what competitive patterns are likely

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[17] Notice that if $\alpha = 0$, i.e., there are no economies of scale, then the only way the high-quality firm can corner the market is if $\gamma > 1 - c$.

to emerge over time. First, we look at the case when firms do not anticipate the emergence of KM. Under this scenario, the size of each firm's initial customer base is assumed to be exogenous, and we explore how this initial customer base is likely to evolve. Subsequently, we look at dynamic competition where firms anticipate the emergence of modern KM systems.

3.2.1. Competing with "Installed Knowledge."
To study the effect of firms' customer base under network effects, we modify Equation (1) of the model in the following way:

$$p_i = 1 + \lambda\alpha x_i + \alpha y_i^e - y_1 - y_2, \quad i = 1, 2. \quad (6)$$

Notice that this formulation is similar to (5) with the difference that $\beta_i = 1$ and $\gamma_i = \lambda\alpha x_i$, where x_i is the commonly known size of firm i's past customer base and $0 < \lambda < 1$ is a discounting parameter. This simple formulation captures the idea that the experience acquired in the past does not get dissipated; it is available to the firm and can also be leveraged using the KM system. However, its value is discounted compared to the value of knowledge originating from recent experience. We will see later that in many respects, this past experience is similar to the notion of installed base in the network externalities literature. For this reason, we will refer to it as "installed knowledge," and for the time being, assume that it is exogenous (each firm is endowed with its prior customer base).

The next proposition characterizes the relationship between the firms' equilibrium outputs.

PROPOSITION 4. *The relationship between the output of the two firms when they both produce positive output in equilibrium is given by*

$$y_1^* - y_2^* = \frac{\lambda\alpha(x_1 - x_2)}{1 - \alpha}. \quad (7)$$

PROOF. Since both firms produce positive output in equilibrium, then it must be the case that their respective best response schedules are satisfied simultaneously. This solution leads to (7). □

It is easy to see that if $\alpha > 1/(1 + \lambda)$, then $y_1 - y_2 > x_1 - x_2$, i.e., an initial difference in customer base is augmented over time. This is likely to occur for higher values of α and/or λ. The converse is true as

well, i.e., if $\alpha < 1/(1 + \lambda)$, initial differences in customer base tend to decrease. In other words, *when KM leads to sufficiently large network effects, large firms tend to become even larger, whereas in the opposite case, initial differences tend to diminish over time.* This finding is consistent with industry evolution for consulting and advertising services. Industry experts point out that, in recent years, size has become an increasingly important advantage for firms: "[...] many mid-size consulting firms have been fearful of some of the changes sweeping the industry, where the largest firms have grown even larger and where very small boutique firms have carved out consulting niches in recent years."[18] The finding helps explain why in the past, when KM was far less effective (i.e., α was relatively small), there was an abundance of spin-offs, where new consulting firms emerged by cutting loose from an existing group. According to the model presented here, at that time starting off with a small client base was not a big disadvantage. With the establishment of modern, more effective KM systems (high α), such behavior should become less frequent (see also Teece 1998, p. 60). In fact, the result suggests that eventually large firms are likely to drive smaller firms out of the market, leading to a shakeout in the industry (see a more detailed discussion after Proposition 5). The result also indicates that—as opposed to spin-offs—firms may actually have an incentive to *merge* in order to increase the size of their installed knowledge. This is clearly observed today with the recent merger wave among consulting and accounting firms. While some of these mergers are partially motivated by the complementarity of the participating firms' products/services, an important motivation is to take advantage of the economies of scale that modern KM offers.[19] A statement by Ellen Knapp,

[18] Wayne Cooper, publisher of *Consultants News*, quoted in *The Wall Street Journal*, 9 Sept. 1998. Similarly, for the advertising industry, Sorrell (1997) notes, "Within [the advertising] industry over the last five to ten years we have seen polarization between the very big and the very small."

[19] In an analysis available from the authors we show that, in an oligopoly, as α increases there is more incentive for at least one merger to take place in the industry. Subsequent mergers are less and less profitable or even unprofitable, which seems to indicate that the "merger move" triggered by modern KM systems should slow down and eventually stop.

Coopers and Lybrand's CKO supports this explanation: "Knowledge management will play a significant role in our pending merger with Price Waterhouse.... we will effectively double our knowledge asset base, broaden our global coverage and enhance our knowledge mix."[20]

3.2.2. Dynamic Competition for Installed Knowledge. In the previous section, we have shown that indirect network externalities generated by modern KM systems might constitute an advantage for larger firms. Until now, our models were static, hence the installed knowledge of firms was exogenous. In this section, we study how this quantity can be determined *endogenously*, by looking at a two-period model in which firms choose the quantity to produce in Period 1 (when KM is not yet available), knowing in advance that this quantity will serve as installed knowledge for Period 2 (when firms compete with KM). Clients can thus benefit from demand-side economies of scale only in Period 2. This scenario is equivalent to assuming that firms anticipate the potential of leveraging the customer base, even though they realize that the appropriate tools and management methods may take time to develop, and thus KM will only be available in the future. In other words, we model the transition period and ask the question, how will firms behave when they foresee that KM can play a key role in determining competitive dynamics?[21]

In each period, firms will choose quantities. Consistent with previous notation x_i and y_i will denote firm i's Period 1 and Period 2 output, respectively. As firms can leverage their installed knowledge, Period 1 output will be an explicit part of the firm's objective function in Period 2, in addition to customer expectations about Period 2 output. Each firm maximizes total profits across the two periods,

$$\pi_i = \left(1 - \sum_{j=1,2} x_j\right) x_i + \left(1 + \lambda \alpha x_i + \alpha y_i^e - \sum_{j=1,2} y_j\right) \times y_i, \quad i = 1, 2. \quad (8)$$

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[20] *Business & Economics Review*, July-Sept. 1998, p.6.

[21] This assumption is consistent with the results of our survey, where at the beginning of 1998, approximately two thirds of the companies were in the process of building a KM system, which would only be up and running by the end of 1999.

We look for subgame perfect equilibria, so that each firm sets its first-period quantity taking into account not only its effect on first-period profits but also on second-period sales. The possible equilibria of this dynamic duopoly setting are outlined below.

PROPOSITION 5. *In a duopoly, there are three possible equilibria depending on the value of α:*
- *for $\alpha < \alpha^0 < 1$ there exists a symmetric equilibrium, $x_1^* = x_2^*$ and $y_1^* = y_2^*$,*
- *for $0 < \alpha^c < \alpha$ there exists an asymmetric equilibrium such that $x_1^* > 0$, $x_2^* > 0$ and $y_1^* > 0$, $y_2^* = 0$,*
- *for sufficiently high λ and α, the asymmetric equilibrium will take the form $x_1^* > 0$, $x_2^* = 0$ and $y_1^* > 0$, $y_2^* = 0$. If $\alpha^c < \alpha^0$, then multiple equilibria exist in the overlapping range, otherwise no equilibrium exists in the range $[\alpha^0, \alpha^c]$.*

PROOF. See the appendix.

What are the implications of Proposition 5? Let us first examine the properties of the symmetric solution, which is the only possible equilibrium for small α. When $\lambda = 0$, the two periods are no longer linked, and first-period profits are identical to those from a standard Cournot model, while second-period profits are identical to those in the completely symmetric one-period solution (§3.1.2). When $\lambda \neq 0$, second-period profits are affected considerably by first-period sales the higher the value of α. In particular, y_i is positively related to x_i and negatively related to x_j. This induces firms to lower prices (increase quantities) in order to accumulate knowledge in the first period. This desire to increase the initial size of the customer base to benefit from a subsequent advantage can be observed in practice. It may help explain why many consulting firms are recently introducing various inexpensive services. A good example is Ernst & Young's "Ernie," an Internet-based consulting service. Initially, Ernie targeted small- and medium-sized organizations that would otherwise not be able to afford hiring a consulting firm. Ernie had tremendous success in the marketplace with thousands of subscribers in the first few months. Interestingly, Ernie has been recently extended to large and established companies as well. Other firms (e.g., former Andersen Consulting) have also announced the introduction

of similar services, which we call "retail consulting services."

Figure 1 traces the total profits of one firm in the symmetric equilibrium as a function of α (for $\lambda = 0.5$). The interesting point to note is that these profits are initially increasing in α, because firms are able to use first-period customer base to increase price and quantity in Period 2, without having to sacrifice too much of first-period profits. However, as we showed in Proposition 4, when α becomes large, each firm is afraid to be at a disadvantage in the second period. Competition for first-period business becomes aggressive, and at some point, total profits begin declining. This leads to the existence of an optimal α for which profits are maximal (e.g., for $\lambda = 0.5$ this α is 0.497). Profits continue to decline thereafter and reach 0 when the symmetric equilibrium ceases to exist. This analysis shows that in contrast to the conclusion from the completely symmetric static case in which higher α leads to higher profits, when firms anticipate the role of KM, better systems do not necessarily imply higher competitive profits across the two periods. Some of the gain that results from the improvement of product quality is dissipated by increased competition.

The equilibrium outlined above also describes a common feature of markets in which (indirect) network externalities occur, namely that such externalities may lead to "winner-take-all" outcomes. One

could argue that the "winner-take-all" aspect of competition mentioned in the discussion of Proposition 4 relies on the unreasonable assumption that some firms exogenously inherit a larger installed knowledge base than others do. Here, we were able to show that one firm can corner the market even if both firms begin at equal starting positions and use the same KM system throughout. This outcome is likely only for relatively high values of α, reinforcing the conclusion from Proposition 4 that the emergence of modern KM systems might lead to a shakeout in the consulting industry. The distinction between the second and third regions of Proposition 5 relates to the timing of any such shakeout. As the ability to leverage past knowledge (λ) increases, the winner-take-all outcome is expected sooner (i.e., in Period l), all else held constant. Our survey seems to support these findings: Most firms do believe that KM systems lead to a *sustainable* competitive advantage.[22] Industry experts directly link this advantage to firm size, pointing to the recent tendency that large firms are driving smaller ones out of the market. "Consulting is a very lucrative business if you've got the critical mass. [...] The industry has had very strong growth over the last 10 years and its profit margins are very good if you have a big enough operation" (see Cooper reference in Footnote 18).

4. Conclusion

In this paper, we made an attempt to analyze the impact of the newly emerging KM concept on competitive patterns for professional services firms. We started by arguing that KM is the basic production technology in this sector and it exhibits economies of scale. With recent growth and globalization and advances in IT, the ability to leverage the customer base has become increasingly important for this industry. Our analysis reveals that in a competitive setting, when the ability to exploit economies of scale is large enough, firms will focus on building

Figure 1   Output and Profits as a Function of α (2-Period Model)
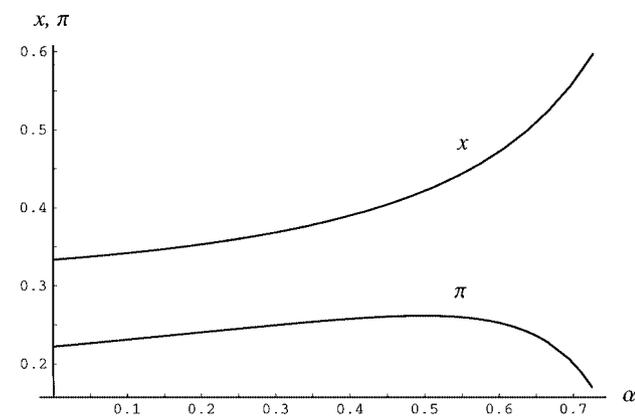
x — Output of each firm
π — Profits of each firm

[22] On a 7-point scale where $1 = not\ at\ all$ and $7 = definitely$, the mean answer to the question "To what extent do you think that a KM system results in a sustainable competitive advantage?" was 6 with a standard deviation of 1.3.

KM systems aimed at creating higher quality products/services to customers. This is in contrast to the optimal choice of a monopolist, who always takes advantage of supply-side scale economies to reduce its production costs. In a second step, we have examined the competitive outcome when firms compete with KM systems aimed at enhancing quality through the integration and synthesis of client assignments.

Our results have important implications for practice. First, they shed light on the current literature exploring the strategic focus of modern KM systems and provide an explanation as to why firms are putting more and more emphasis on the quality-improving aspect of their KM systems (knowledge creation). Furthermore, the analysis highlights the incentives underlying competitive dynamics in the KM era. The results support a number of recent industry trends. They are consistent with the recent merger wave in consulting, which is in sharp contrast to the traditional industry practice where a few professionals would break out of larger firms to form start-ups. With the emergence of effective KM systems, the individual expertise or skill of a single consultant becomes less relevant for attracting clients who favor larger firms because of their larger base for learning. The results also explain why many large consulting firms introduce inexpensive consulting services. Again, while these services certainly contribute to the firms' bottom lines, we suggest that they also have a role in increasing the installed knowledge base of the consulting firm through faster customer (project) acquisition. Finally, technologies exhibiting increasing returns, such as KM, favor early timing and require a careful management of expectations. Our model helps explain the general hype about KM in the industry and the vast resources that firms invest in building and marketing KM systems.

Our paper is based on an aggregate industry model to shed light on the dynamics of competition under a new production technology: knowledge management. There are important institutional details that the current framework is not well suited to address. In fact, given the short history of KM, there is no standard recipe to build successful KM systems. What is the best way to implement KM processes in order to achieve desired strategic objectives, and how does this decision depend on the firm's business context? What organizational structure and incentive schemes are needed to guarantee sufficient input and proper usage of the KM system by members of the organization? These are important questions for future research.

Finally, at a more theoretical level, our model is the first to explore the endogenous choice of different types of scale economies by competing firms. In this context, firms can influence the extent to which customer expectations play a role in their demand. As we have argued before, this framework is relevant to the particular context of professional services firms, where the appropriate design of the "KM technology" may lead to either indirect network externalities or supply-side economies of scale. However, this problem might be more general and applicable to other production technologies or industry contexts. One example is the design of competing community-based Internet brands (e.g., iVillage.com vs. women.com). Here, firms face a dilemma similar to the KM system design. They can either leverage experience to make the transactional features of their business more efficient (e.g., better logistics, achieve lower acquisition costs through effective targeting) or they can invest in better means to build community (e.g., monitoring online chat to make the site more relevant for their customers). As a general rule, it seems that the current framework is applicable to industries in which firms can generate content (knowledge) from their customer base.

Acknowledgments

Appendix

PROOF OF PROPOSITION 2. We start by showing that the proposed equilibria exist. We do this by looking at all deviations in β from the proposed equilibria. Throughout the proof, we assume that c is in the relevant range, i.e., $\alpha/(2-\alpha+\beta_i\alpha) < c < 1$ (so that cost reduction is a viable strategy).

Assume first that $\alpha < 1/(2-\beta_L)$ and that both firms choose β_L. Then, solving (4) for the equilibrium of the output game, and plugging the result in the firms' profit functions, we obtain the following profits:

$$\pi_1^* = \pi_2^* = \frac{(1-c)^2(1-\alpha+\alpha\beta_L)}{(3-2\alpha+\alpha\beta_L)^2}. \tag{9}$$

Assume, that Firm 1 considers to deviate by choosing $\beta_1 > \beta_L$. Then, solving (4) again, its profits would be

$$\pi_1 = \frac{(1-c)^2(1-2\alpha+\alpha\beta_L)^2(1-\alpha+\alpha\beta_1)}{(3+\alpha^2(\beta_L-2)(\beta_1-2)+2\alpha(\beta_L+\beta_1-4))^2}. \quad (10)$$

Differentiating this expression by β_1, one can establish with tedious calculations that $\partial\pi_1/\partial\beta_1$ is negative for any β_1. Since $\beta_L < \beta_1$, by continuity, the deviation is unprofitable. Therefore, (β_L, β_L) is an equilibrium.

When $\alpha > 1/(2-\beta_L)$, there may exist multiple output equilibria in the second-stage game, depending on firms' choice of βs and customer expectations. We consider all such equilibria, and assume that a firm with a lower β than its rival, hence capable of offering less value to clients, will not be expected by customers to be a monopolist unless there are no other expectations that can be fulfilled in equilibrium. When $1/(2-\beta_L) < \alpha < 1/(2-\beta_H)$ in the proposed equilibrium, $\beta_1 = \beta_2 = \beta = (2\alpha-1)/\alpha$. Assume first that Firm 1 unilaterally deviates by choosing $\beta_1 > (2\alpha-1)/\alpha$. It can be shown that the only expectation that can be fulfilled in the second stage is $y_1^e = 0$; therefore, $\pi_1 = 0$. Hence, irrespective of what profits are in the proposed equilibrium, this is not a profitable deviation. Next assume that Firm 1 decreases its β by choosing $\beta_1 < (2\alpha-1)/\alpha$. Then, given our assumptions on customer expectations for winner-take-all outcomes, there is no possible output equilibrium where it is expected to have positive output.

Finally, take the case when $\alpha > 1/(2-\beta_H)$. If both firms are expected to have positive output, equilibrium profits are

$$\pi_1^* = \pi_2^* = \frac{(1-c)^2(1-\alpha+\alpha\beta_H)}{(3-2\alpha+\alpha\beta_H)^2}. \quad (11)$$

Consider a deviation by Firm 1 to lower its β. Then profits become

$$\pi_1 = \frac{(1-c)^2(1-2\alpha+\alpha\beta_H)^2(1-\alpha+\alpha\beta_1)}{(3+\alpha^2(\beta_1-2)(\beta_H-2)+2\alpha(\beta_1+\beta_H-4))^2}. \quad (12)$$

Following the same procedure as above, one can show that $\partial\pi_1/\partial\beta_1 > 0$ for any β_1. As $\beta_H > \beta_1$, the deviation is unprofitable. If, on the other hand, given the choice of βs consumers expect one of the firms to be a monopolist, still no deviation by any of the firms would make it better off as the deviating firm would make 0 profits. Therefore, (β_H, β_H) is an equilibrium.

Uniqueness in the choice of β_i can be proved using the same logic, by showing that in the corresponding regions there is a profitable deviation from any pair (β_1, β_2), which is different from the ones proposed in the proposition. $\square$

PROOF OF PROPOSITION 3. The proof follows practically the same steps as those of Proposition 2. First, assume that $\alpha < (1-\gamma/(1-c))/(2-\beta_L)$. Then the proposed equilibrium is (β_L, β_L). Assume that Firm 1 deviates to $\beta_1 > \beta_L$. Then its profits are

$$\pi_1 = \frac{[1-c-\alpha(2-\beta_L)(1-c+\gamma)+2\gamma]^2(1-\alpha+\alpha\beta_1)}{(3+\alpha^2(2-\beta_1)(2-\beta_L)-2\alpha(4-\beta_1-\beta_L))^2}. \quad (13)$$

Notice that with $\gamma = 0$, this expression is identical to (10). Furthermore, it can be shown that it decreases in β_1. Thus, any $\beta_1 > \beta_L$ is not a profitable deviation. Similarly, if Firm 2 deviates, we have

$$\pi_2 = \frac{[1-c-\alpha(2-\beta_L)(1-c)-\gamma]^2(1-\alpha+\alpha\beta_2)}{(3+\alpha^2(2-\beta_L)(2-\beta_2)-2\alpha(4-\beta_L-\beta_2))^2}, \quad (14)$$

which is also identical to (10) if $\gamma = 0$, and it also decreases in β_2. Thus, Firm 2 does not have an incentive to deviate either.

Next, take the case when $(2-(1-c)/(1-c+\gamma))/(2-\beta_L) > \alpha > (1-\gamma/(1-c))/(2-\beta_L)$ and assume that Firm 1 chooses $\beta_1 = \beta_L$, then for every β chosen by Firm 2, the only expectation that can be fulfilled is $y_2 = 0$. Hence, based on the conclusions of Proposition 1, $\beta_1 = \beta_L$ is in fact optimal for Firm 1.

Finally, if $\alpha > (2-(1-c)/(1-c+\gamma))/(2-\beta_H)$, under the same assumptions as in the proof of Proposition 2 regarding winner-take-all expectations, the proposed equilibrium is (β_H, β_H). When both firms are expected to produce positive output and Firm 1 deviates with $\beta_1 < \beta_H$, it earns profits

$$\pi_1 = \frac{[1-c-\alpha(2-\beta_H)(1-c+\gamma)+2\gamma]^2(1-\alpha+\alpha\beta_1)}{(3+\alpha^2(2-\beta_1)(2-\beta_H)-2\alpha(4-\beta_1-\beta_H))^2}. \quad (15)$$

These profits are increasing in β_1 and $\beta_1 < \beta_H$, so it is not worthwhile for Firm 1 to deviate. For Firm 2, a deviation earns profits equal to

$$\pi_2 = \frac{[1-c-\alpha(2-\beta_H)(1-c)-\gamma]^2(1-\alpha+\alpha\beta_2)}{(3+\alpha^2(2-\beta_H)(2-\beta_2)-2\alpha(4-\beta_H-\beta_2))^2}, \quad (16)$$

which are also increasing in β_2, so Firm 2 does not have an incentive to deviate either. If, on the other hand, given the choice of βs consumers expect one of the firms to be a monopolist, still no deviation by any of the firms would make it better off.

Uniqueness of the proposed equilibria can be proved by showing that for each other combination of (β_1, β_2), there is a profitable deviation for the firms. Similarly, when $(2-(1-c)/(1-c+\gamma))/(2-\beta_L) < \alpha < (2-(1-c)/(1-c+\gamma))/(2-\beta_H)$, there is no equilibrium, because for each pair of (β_1, β_2), Firm 1 can profitably deviate. $\square$

PROOF OF PROPOSITION 5. To determine the subgame perfect equilibria, we first solve for the second period fulfilled expectations equilibrium choice of quantities as a function of the Period 1 output vector and use backward induction to then solve for the equilibrium of the entire game. We assume no discounting of profits across periods (such discounting does not qualitatively affect the results).

I. The Second Period. To obtain the equilibrium of the second period subgame as a function of any arbitrary vector $\vec{x} = (x_1, x_2)$, we distinguish between two cases:

Case 1. No firm can monopolize the market in Period 2. Formally, this means that the condition

$$\lambda\alpha x_2 \leq \frac{\lambda\alpha x_1 - (1-\alpha)}{2-\alpha} \quad (17)$$

does not hold. In this case, we must simultaneously solve

$$\begin{cases} 1 + \lambda\alpha x_1 + \alpha y_1 - \sum_{j=1,2} y_j - y_1 = 0 \\ 1 + \lambda\alpha x_2 + \alpha y_2 - \sum_{j=1,2} y_j - y_2 = 0. \end{cases} \quad (18)$$

The second-period equilibrium quantities are given by

$$y_i^* = \frac{1-\alpha+(2-\alpha)\lambda\alpha x_i - \lambda\alpha x_j}{(1-\alpha)(3-\alpha)}. \quad (19)$$

For each firm, (19) gives us the optimal choice of quantity in Period 2 as a function of the Period 1 output vector.

Case 2. If Condition (17) is satisfied, and assuming without loss of generality $i=1$, $j=2$, then the fulfilled expectations equilibrium with nonnegative outputs in the second period is

$$y_1^* = \frac{1+\lambda\alpha x_1}{2-\alpha}, \quad y_2^* = 0. \tag{20}$$

II. The First Period. To determine the first period subgame perfect output, we must first characterize the set of possible equilibria for the entire game, which are (i) both firms produce in both periods; (ii) one firm produces in both periods, while the other produces only in Period 1, dropping out in Period 2; and (iii) one firm produces in both periods, while the other drops out immediately. It turns out that the existence of these three possibilities depends primarily on α.

Both Firms Active in Both Periods. When both firms are active in both periods, we substitute (19) into (8) to obtain total profits as a function of Period 1 output only. For Firm 1 this becomes

$$\pi_1 = \left(1 - \sum_{j=1,2} x_j\right)x_1 + \left(\frac{1-\alpha+(2-\alpha)\lambda\alpha x_1 - \lambda\alpha x_2}{(1-\alpha)(3-\alpha)}\right)^2. \tag{21}$$

The form of the profit function for Firm 2 is identical (one needs to simply replace the indices appropriately). Letting each firm optimize, taking the quantity of the other firm as given, leads to two equations that can simultaneously be solved to yield

$$x_1^* = x_2^* = \frac{(1-\alpha)(3-\alpha)^2 + 2\lambda\alpha(2-\alpha)}{3(1-\alpha)(3-\alpha)^2 - 2\lambda^2\alpha^2(2-\alpha)}. \tag{22}$$

The solution in this case is always symmetric.[23]

One Firm Drops Out in Period 2. If Firm 2 drops out, we use (20) to express second period profits, so (8) becomes

$$\begin{cases} \pi_1 = \left(1 - \sum_{j=1,2} x_j\right)x_1 + \left(\frac{1+\lambda\alpha x_1}{2-\alpha}\right)^2 \\ \pi_2 = \left(1 - \sum_{j=1,2} x_j\right)x_2. \end{cases}$$

Solving for the equilibrium in this case yields

$$x_1^* = \frac{(2-\alpha)^2 + 4\lambda\alpha}{3(2-\alpha)^2 - 4\lambda^2\alpha^2}, \quad x_2^* = \frac{1-x_1}{2}. \tag{23}$$

For these quantities to be an equilibrium of the entire game, we must check that in fact Firm 2 does not have an incentive to deviate and produce in Period 2. This imposes a constraint on α. We establish this constraint below showing that there is a *critical level* α^c such that for $\alpha^c < \alpha$ an equilibrium where both firms are active in the first period but only one is active in the second exists. This critical level of α is inversely related to λ.

[23] We ignore knife-edge cases in which both firms are active in both periods and ($x_1 \neq x_2$).

One Firm Drops Out Immediately. When in (23) $x_1^* = 1$, then Firm 2 will in fact choose to drop out immediately (subject to the constraint that $\alpha^c < \alpha$, see below). In this case, Firm 1 acts as a monopolist in both periods and sets quantities as follows:

$$x_1^* = \frac{(2-\alpha)^2 + 2\lambda\alpha}{2(2-\alpha)^2 - 2\lambda^2\alpha^2}, \quad y_1^* = \frac{1+\lambda\alpha x_1^*}{2-\alpha}. \tag{24}$$

The existence of this equilibrium depends on λ being sufficiently large so that in fact $x_1 = 1$ in (24) is possible.[24]

The Critical Level of α for Firm 2 to Drop Out in the Second Period. For the solution in (23) to be subgame perfect, we must require that given these optimal quantities, in fact neither firm wishes to deviate in the second period. Since we assumed that in Period 2, Firm 2 produces zero output, then it must be that

$$1+\lambda\alpha\left(\frac{1-x_1}{2}\right) < \frac{1+\lambda\alpha x_1}{2-\alpha} \quad \text{or} \quad \frac{2(1-\alpha)+\lambda\alpha(2-\alpha)}{4\lambda\alpha - \lambda\alpha^2} < x_1.$$

Given the solution for x_1 per (18), we need

$$\frac{2(1-\alpha)+\lambda\alpha(2-\alpha)}{4\lambda\alpha-\lambda\alpha^2} < \frac{(2-\alpha)^2+4\lambda\alpha}{3(2-\alpha)^2-4\lambda^2\alpha^2}.$$

This condition is satisfied for values of α such that

$$\frac{-3+\sqrt{1+16\lambda^2}}{2(2\lambda^2-1)} < \alpha.$$

Denoting the left-hand side of the inequality above α^c, it can easily be shown that $\partial\alpha^c/\partial\lambda$ is negative. □

[24] As x_1^* in (24) is increasing both in α and λ, it is enough to check for what value of λ, $x_1 = 1$ occurs exactly at $\alpha = 1$. We have calculated this lower bound to be $\lambda = 0.366$.

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