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Institutional Forms, Part 3: Monopoly and Cluster

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1 A Local System Based on Information, Property Rights and Directed Employment

In our Base Case and in our analysis of the Guild, we assumed that there was no way to bridge the communication gap between designers and users. Users could verify that designers' services were valuable after the fact. But (we assumed) users had no way of ranking problems, nor of knowing the financial value of solutions to different problems. Designers, for their part, could rank problems and their solutions using functional criteria (x and R(x)), but did not know the corresponding financial value of solving any problems.

We will now relax the assumption of an unbridgeable communication gap, and look at a local system based on (economic) information, property rights and directed employment. In this environment, we shall see, firms specializing in "the business" of design can emerge and operate on the Q(k) technological substrate. Such firms will employ designers and sell products or services that embody the best of their designs. The ambition of these firms (or their owner-managers) is to establish a long-term, sustainable Monopoly in some problem domain.

But we shall also see that this ambition cannot always be realized: in equilibrium, a Monopoly may coexist with a Cluster of smaller firms, or the Cluster may be the dominant institutional form, and exist by itself. Thus a Cluster is both a complement and an alternative to a Monopoly in any given problem domain. A key goal of our analysis is to discover under what circumstances one or the other form will survive and/or dominate in the long run.

Both the monopoly and the cluster are based on a new type of firm, whom we label a "specialist-firm." Like the user-firms in the Base Case, the specialist-firms employ designers. However, unlike the user-firms:

- Specialist-firms sell solutions to specific problems ("designs") to user-firms; hence user's willingness to pay, Q(k), is the source of their potential revenue;
- Under the terms of their employment contract, the specialist-firms can direct designers to work on some problems and not others;
- The owner-manager of these firms know the *ex ante* financial value of solving a problem as a function of the number of designers working on it; in other words, the owner-manager knows the Q(k) functions for some problems.

In Institutional Forms, Part 1, we said that two of the generic problems of the Q(k) technological substrate were: (1) how to get the best known solution to a problem used wherever appropriate; and (2) how to get designers to choose problems in a socially efficient manner. Solving these problems requires both *ex post* collective action (a pooling of solutions) and *ex ante* coordination of their efforts. In Institutional Forms, Part 2, we saw that a "Guild" with a library and signup sheets offers one way of solving these problems. In this paper, we will show that a "Monopoly-or-Cluster", which employs designers and sells their solutions, offers another way of solving the two generic problems. Thus in the Q(k) technological substrate, the Guild and the Monopoly-or-Cluster are competing institutional forms: they do the same things but in different ways and with a different distribution of rewards to the participants.

[Insert overview of sections to follow.]

2 The Emergence of Specialist-Firms from the Base Case Environment

Recall that in the Base Case, neither designers nor user-firms could "see" the financial value of supplying solutions to any of known problems. To fix ideas, let us consider a single problem. As before, let v(x) represent the money a user would be willing to pay for a solution of quality x to this problem; let F(v) denote the distribution of economic payoffs associated with a single designer's effort to solve this problem; and define Q(k) as follows:[1]

$$Q(k) = w \int_{-\infty}^{w} k\, F(v)^{k-1} f(v)\, dv \quad + \int_{w}^{\infty} v\, k\, F(v)^{k-1} f(v)\, dv \quad .$$

In words, Q(k) is the expected value of the *most valuable solution* among k independent solutions drawn from the distribution F(v). Solutions that are worth less than w (the benchmark) are replaced by w. This truncation reflects the designer's option to fall back on the previously known, "textbook" solution, whose financial value is w by assumption.

A problem can occur more than once. Let N denote the number of instances of the problem in the greater economy. NQ(k) is then the *expected revenue* that could be obtained by pooling the efforts of k designers and selling the best of their solutions to all users who face the problem. Note that this number is the product of the frequency of the problem times the potential to improve on the textbook solution.

Now suppose that in the Base Case institutional equilibrium, a single agent comes to know NQ(k) for a subset of the known problems. We assume that the agent is a risk-neutral value maximizer, hence can be thought of as a firm. The firm's ambition is to realize the net financial value that can be obtained by "arbitraging" designers wages against the revenue potential of NQ(k). We will call this firm the "would-be monopolist" or simply the "monopolist" for short.

Recall that in the Base Case institutional equilibrium, there was no pooling of solutions and no coordination of task assignments. The would-be monopolist can take advantage of that situation by creating a private pool of solutions. It can then offer designers access to the pool in return for their agreement to expend incremental effort on the problems that the monopolist designates.

In specifying the designers' motives in the Base Case, we said that they valued knowing solutions. Thus access to the monopolist's private pool should be of value to them. However, their ranking of problems may differ from that of the monopolist because $R(.) \neq NQ(.)$, and therefore the monopolist's offer may not strictly dominate the opportunity to work on self-selected problems at a user-firm. We assume that the monopolist can address that shortfall if it exists via one or more of the following measures: (1) hiring more designers (thereby increasing the value of its internal pool in the eyes of designers); (2) hiring designers with an "affinity" for the problems the monopolist wishes to solve; (3) hiring designers who value supervision; and (4) increasing the wages of its designers. Through some combination of these mechanisms, we assume that the would-be monopolist can become competitive with user-firms as an employer in the eyes of (some) designers.

The would-be monopolist can also offer an attractive proposition to user-firms, its potential customers. Its pool of solutions dominates in expectation the "one-off" solutions generated by the isolated designers at the user-firms. In addition, outsourcing some designs may free up the capacity of the user-firms' inhouse problem solvers. However, in order for the would-

[1] This definition is identical to the one given in Section 3.2 of Institutional Forms, Part 1.

be monopolist to sell its services to user-firms, it first needs to become known to them. And in our sticky Base-Case economy, becoming known entails transactions costs.

Given transactions costs, it makes sense for the budding monopolist to specialize in a small number of problem types, with high expected revenue and low design costs ($NQ(k) - \omega k >> 0$). For example, here is one possible strategy, which the monopolist might adopt: It initially hires k designers for a contract interval T at per-period wage ω. It directs the designers to work one problem per problem-solving interval, taking the problems from a designated set. At the end of the contract interval, the monopolist will have an inhouse set of T solutions, with *ex post* values:

$$[Q_1^*(k), Q_2^*(k), \ldots , Q_T^*(k)] \quad .$$

In expectation, each of these will be better than the textbook solution. Out among the user-firms, there may be even better solutions, but these will be scattered and unknown except to their own authors. (Recall that in the Base Case environment, there is no Guild to publish solutions.)

Even before the end of the first contracting interval, the monopolist can begin to advertise problem-solving services of the form: "If you have one of these problems, do not solve it yourself, call us instead." Advertising these services to users (or, more likely, the designers in user-firms) entails transactions costs, but if the problems are common (large N) and/or sufficiently important (large Q(k)), then the expected and actual revenues can overcome the transactions costs.[2] In that case, the would-be monopolist will be sufficient, and by the rules of our model world, it can then come into existence.

As the fledgling monopolist begins to advertise, it will create an ancillary benefit. As the monopolist markets its solutions to user-firms, it may encounter designers at those firms who have already developed superior solutions to one or more of the monopolist's problems. The monopolist can and should hire those individuals, and incorporate their solutions into its own pool of solutions. We call those individuals "specialists" in the monopoly's problem solving

[2] Indeed one can envision many gradual transition paths, which would enable the fledgling monopolist to start small and grow by incremental steps. In this fashion, it can use the profits of the last round of problem-solving to finance the next round. This is an example of the "exclude-then-augment" modular strategy applied at the level of an enterprise.

domain. Initially the employment contracts with specialists should be relatively easy to arrange. Recall that, in the Base Case, neither user-firms nor designers know the financial value of their own solutions: only the monopolist "sees" that value. Therefore, the monopolist should be able to offer specialists superior terms of employment, while paying them close to the going wage, ω. It can do so because it has an inhouse pool of solutions that are not available anywhere else. Later though, as we shall see, the initial employment terms may not suffice.

When the monopolist comes into existence, a new local system will have been "born" on the Q(k) technological substrate. As with all local systems in our framework, its purpose is to address the generic problems of the substrate: (1) getting the best known solution to a problem used wherever appropriate; and (2) getting designers to choose problems in a socially efficient manner . By creating a pool of solutions and by encouraging designers at user-firms not to solve "its" problems, the would-be monopolist improves on the Base Case on both these dimensions.

However, we must stress again that a local system is not necessarily an institution in the sense defined by Aoki (2001). A local system may be a transient or temporary form. To be an institution, the local system must not only come into existence, but must also arrive at an *equilibrium sustained by beliefs that recreate the equilibrium at each round of "the game."* We shall see below that arriving at such an equilibrium is not easy: in fact, although transient monopolies can emerge quite easily on the Q(k) substrate, very special conditions are required in order to have a "monopoly institution."

Nevertheless the Base Case environment offers fertile ground for the emergence of a monopoly. The risk is that those monopolies that do emerge will not remain monopolies for long. As we have set up this analysis, the only thing that sustains a monopoly is the fact that "only one" agent "knows" the NQ(k)s of a subset of problems. Even if true initially, this assumption is unlikely to remain true for very long: the very existence of the monopoly reveals something about the NQ(k)s of the problems it proposes to solve. And it cannot keep the identity of those problems a secret, and at the same time advertise its problem-solving abilities to potential customers!

Indeed, the fledgling monopoly is most at risk of competition from its own employees. These individuals, after all, can not only infer the NQ(k)s of problems in the monopolist's domain, but will also know the in house solutions. Thus in order to sustain its monopoly position, the initial monopolist needs *cheap and effective* ways to exclude others from using the design solutions developed under its aegis. Mechanisms of exclusion may include:

- court-enforceable property rights (e.g., patents, copyrights, trade secrets);
- court-enforceable contracts (e.g., non-compete agreements);
- technological barriers (e.g., encryption, complexity, or information hiding).

The first two of these mechanisms must "come from" the greater economy; the third can arise as a result of the monopolist's own actions. The three mechanisms are complementary: what the monopolist most needs is a cheap and effective combination.[3]

Insert and discuss the Graphical Overview.

2.1 What If There Are No of Mechanisms of Exclusion?

It is worth pausing at this point to ask, "What if the above-named mechanisms of exclusion do not exist or are costly and ineffective?" Can we predict the trajectory of the emergent local system under those conditions? Indeed we can: in such circumstances, we expect the monopoly to be short-lived, and its employment patterns unstable. The long-run institutional equilibrium will look quite different.

In particular, as the initial monopolist's designer-employees learn the mysteries of Q(k), we expect that they would want to improve their condition by claiming part of the financial surplus. They could accomplish this is one of two ways:

- by spinning themselves out, and creating a new problem-solving firm or firms; or
- by getting stock or a share of the profits of the initial firm.

The first of these alternatives serves as a credible threat that may induce the initial owner of the monopoly to agree to the second alternative. By assumption, the initial monopoly has no inherent property rights, nor contractual rights, nor technologies by which to prevent its in house

[3] Lessig, Code.

solutions from simply "walking out the door." Without any of these devices, the initial monopoly is bound to lose the "game against its own employees."[4]

The end result of this particular evolutionary trajectory is an institutional equilibrium in which:

- Specialized problem-solving firms exist side-by-side with user-firms who are their clients and customers;
- The specialized firms are owned primarily by the designers who work in them;
- Each specialist-firm maintains an inhouse "pool" of solutions, however, each has great difficulty maintaining exclusive rights over that pool;
- Each specialist-firm's main competition arises from its own "descendants," i.e., firms founded by its own former employees;

In general, the higher the transactions costs involved in forming new firms, the larger and more profitable the specialized firms will be.

Also there will be strong incentives within the specialist-firms to organize their own internal problem-solving so as to protect and encrypt their own solutions. Ironically, though, such efforts to protect the firm's "franchise" by controlling and partitioning internal knowledge will make those firms less attractive places to work. Hence a delicate balance needs to be struck at each specialized firm between its "recruiting" and its "retention" policies.

2.2 And If There Are Mechanisms of Exclusion?

We now turn to the main focus of our analysis: the nature of a design monopoly when there *are* cheap and effective mechanisms of exclusion. We begin by noting that there are two levels of exclusion: the problem level and the solution level. A monopolist may be said to "own its problem(s)" if it can exclude others from searching in its problem domain. It "owns its solutions" if it has court-enforceable property rights or contractual rights or effective technologies that prevent others from copying its completed designs. Obviously "owning the problem" is a much stronger form of exclusion, and confers more market power than "owning the solution."

In the US, intellectual property law in the form of patents and copyrights generally protect the structural aspects of a design, hence they confer strong ownership rights to solutions. But the same laws confer much weaker ownership rights to problems. Still, in modular systems,

[4] We can frame this as the absence of a relational contract.

there are several ways in which monopolists can assert control over problem-solving domains. For example, a firm can exercise control over a modular system's *visible information*— its architecture, interfaces and tests. Interfaces, in particular, are both completed designs in their own right, and a path of access to the problem domains of *hidden modules*. Therefore, in the space of designs, owning an interface is like owning a gateway: it can be parlayed into rights of exclusion over domains that can only be accessed through the interface. We will return to these issues in the empirical parts of our investigation.

In the previous section, we showed that a monopolist firm can initially emerge and grow by creating an internal pool of solutions, recruiting designers to work on those designated problems, and selling its services to user firms. Over time, we said, the monopolist would attract and employ specialists in its problem-solving domain. We now assume that the monopolist can protect its own solutions from use by others: those who want to use the solutions in its pool must pay to do so.

For now, we assume that the monopolist offers one product. In the problem domain of computers, the product might be a disk drive, a CPU, a memory device, or a software package.[5] Consistent with our previous notation, the number of potential users of the product is N; the number of designers hired by the monopoly and set to work on its problems is k; and the expected revenue (per user) of the best of k designs is given by the function Q(k). The monopolist knows both N and Q(k).

Consistent with our Base Case assumptions, we assume that a would-be monopolist can initially employ designers at the going efficiency wage, ω, for some contract interval, T, which corresponds to the time needed to design the product. We also assume that creating the monopoly enterprise and "packaging" the product involves frictional transactions costs, which have both fixed and variable components:

$$\text{Transactions Costs} = A_M T + B_M \ .$$

[5] The extension of this analysis to multiple products is straightforward, but notationally cumbersome. Later in the analysis, we shall endogenize the boundaries of the monopolist and the scope of its products.

In this expression, there is a fixed per-period cost of doing business, A_M, and an *ex ante* cost, B_M, which is the cost of setting up the monopoly enterprise.[6]

If the monopoly can charge all users their full willingness to pay for the product, then the *ex ante* net financial value of the monopoly , $NFV_M(k)$ is:

$$NFV_M(k) = NQ(k) - \omega T k - A_M T - B_M \quad . \tag{1}$$

We now consider the monopoly's optimal (first-best) strategy. The monopolist has two decisions: whether to enter and, conditional on entry, how many designers to employ. We assume that the monopolist will enter if it is *ex ante* sufficient, that is, if the NFV(M; k) calculation above is positive.[7] Notice that, in the presence of sunk transactions costs, B, there is a barrier to entry: it is harder for a new monopoly to form than for an existing one to continue.

The sufficiency calculation in turn depends on how many designers the monopolist decides to hire. The transactions cost terms in Expression 1 do not depend on k, thus we can focus on the subproblem:

$$\max_k \; N\,Q(k) - \omega T k \quad . \tag{2}$$

NQ(k) is increasing and concave, while ωTk is increasing and linear in k. Therefore Expression 2 forms an inverted "U", as depicted in Figure 2.

A value-maximizing monopolist would like to select k such that the marginal product of the last designer hired is positive, while the marginal product of the next designer hired is negative. Let k* be defined in this fashion:

$$k^* \equiv \min \; k \text{ such that } N[Q(k+1) - Q(k)] - \omega T \leq 0 \; .$$

In Figure 2, k* = 8. For the monopolist, setting k = k* maximizes Expression 2, which in turn maximizes the net financial value of the monopoly in Expression 1.

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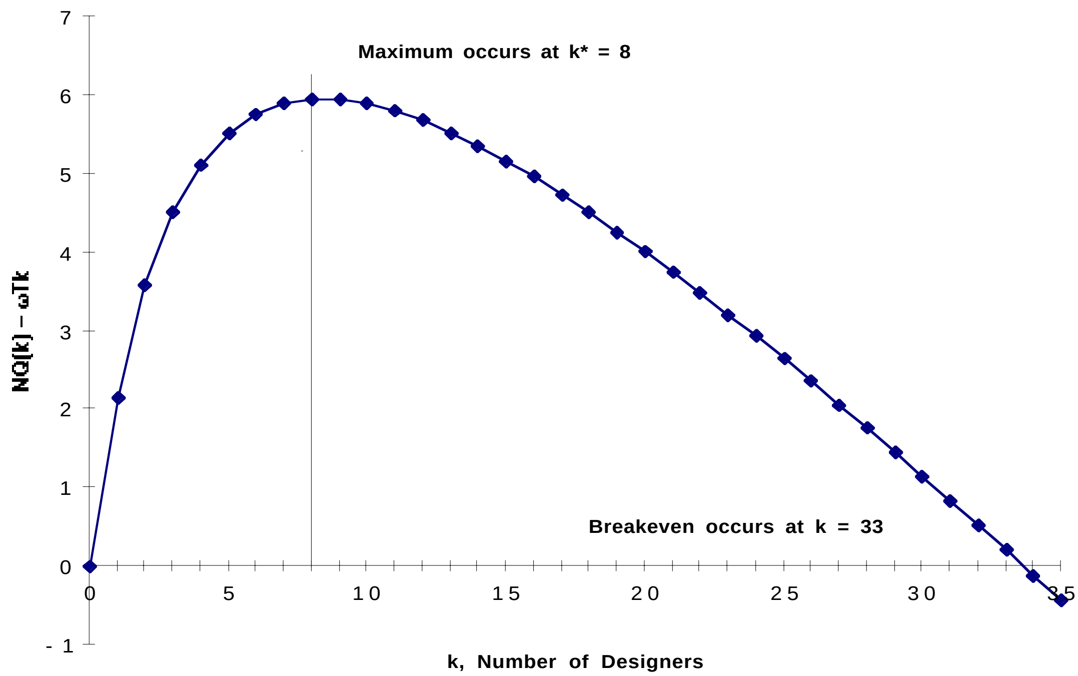
[6] For notational simplicity, per-instance transactions costs are subsumed in v(x), hence Q(k).

[7] Under rational expectations, only monopolies that satisfy this constraint can come into existence and sustain themselves as ongoing Aoki-type institutions. See the discussion of local systems and sufficiency in Institutional Forms, Part 1.

Figure 2
A Representative NQ(k) – ωTk Function



Proceeding mechanically, it appears that if:

$$NFV_M(k^*) \;=\; N\,Q(k^*) \;-\; \omega T k^* \;-\; A_M T \;-\; B_M \;\geq\; 0 \;\;,$$

then the monopoly is sufficient. In that case, by the rules of our model world, the monopoly should be able to become a self-sustaining equilibrium of shared beliefs "constructed on" the opportunities of the Q(k) technological substrate.

These results apply as long as the monopolist can restrict entry to the whole problem-solving domain. If the monopolist "owns the problem," or if it can keep knowledge of the payoffs a secret, then our analysis would be done. But, as we indicated above, that assumption may not hold: property rights and technologies of exclusion may work so that the monopolist only "owns its solutions," In that case, others will have the ability and the right to enter the monopolist's problem domain and try out new designs as well.[8]

The value and sufficiency of the monopoly will depend on what those others, whom we call the "outside designers," choose to do. And the outside designers' options in turn will be influenced by the actions taken and beliefs engendered by the monopolist. Therefore, in our model world, the local system of a monopoly cannot be deemed sufficient, nor can it be an Aoki-type institution, until we analyze the equilibria of "the game" between the monopolist and the outside designers and their firms. We turn to this task in the following sections.

3 The Basic Game between a Would-be Monopolist and Potential Entrants

In the rest of this paper, we will assume that property rights exist but are incomplete, and that knowledge of financial value is widespread but imprecise. Under these over-arching conditions, we will see whether a "design monopoly" can become an Aoki-style institution—that is, can it be the equilibrium of a game defined on the Q(k) technological substrate? If so, under what conditions, and is the equilibrium unique or one of several?

From now on we will assume that agents in our model world have effective property rights over complete designs, but do not exercise property rights over problem domains. In our jargon, agents "own their solutions," but do not "own their problems." As a result, a would-be monopolist cannot exclude others from searching for better designs in its own problem domain. We further assume that, in addition to the would-be monopolist, there are an unlimited number of risk-neutral agents who know NQ(k). Like the monopolist, these potential "entrants" have access to capital. Thus they can come into existence if they are *ex ante* sufficient.

Formally, let the monopolist and potential entrants participate in a three-stage design process and game as shown in Figure 3. The monopolist is assumed to move first: in Stage 1A, it hires some number of designers. The designers it hires are no better or worse than those

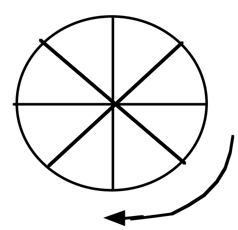
[8] This is a pretty subtle difference, on which hinges the nature of the whole design economy! We need to talk about that at some point. Cf. Lessig, both books and cites therein. Note that in the previous section, the monopolist owned neither its problems nor its solutions.

remaining "outside." In Stage 1B, knowing what the monopolist has done, entrants decide whether to enter. We assume that each potential entrant can hire one of the qualified outside designers: thus each actual entrant increases k by 1.[9] In addition, we assume that entrants are symmetric in that each has the same knowledge and faces the same transactions costs.

Figure 3
The Stage-Game between Monopolist and Entrants

Stages	1A	1B	Stage 2	Stage 3
Time Line	**Monopolist Moves; Hires Designers**	**Entrants Decide Whether to Enter**	**Carry Out Design Tasks**	**The "aftermarket" Test Designs; Exercise Options**

What Actually Happens

Events	Monopoly raises capital; hires designers.	Entrants raise capital; hire designers.	*"The Wheel Spins"* 	Economic value is revealed; best design is selected. Losing entrants withdraw; monopolist might stay in.

In Stage 2, the designers hired by the monopolist and the entrants work to develop their designs. Figuratively, one can imagine that "a wheel spins" and determines the value of each design. Mathematically, one can model the "spinning wheel" as a draw from the probability distribution associated with the random-variable payoff function.

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[9] It is not necessary to consider the case wherein an entrant can hire more than one designer, because it is the last single entrant that matters in the analysis.

In Stage 3, which we label "the aftermarket," the value of each new design is revealed, and the outcomes are ranked according to their value.[10] At this point the players-firms have "options": they can "stay in" or "withdraw." If a firm stays in the aftermarket, it will package its design as a product and sell it. If a firm withdraws, its design will simply disappear.

We now need to introduce some notation that will carry us through the next several sections. We shall see that designers fall into a number of strategic categories, for example:

- designers hired by the monopolist under first-best conditions;
- designers hired by entrants;
- "excess" designers hired by the monopolist as part of an entry-deterring strategy.

These and other categories will be defined below, as we explore the strategy space of the monopolist and the entrants.

In general, the number of designers in each category is endogenously determined in equilibrium: each is a function of the structure of the game, certain parameters, and the beliefs on which the players' expectations are constructed. In what follows, we will consistently use lower-case letters to denote variables (things to be chosen by the players). And we will use stars to denote equilbrium outcomes (choices that have been made). For example, in the previous section, k denoted the number of designers that could be hired; k* denoted the actual number the monopolist would choose to hire under first-best conditions. In Figure 2, k ranged from 0 to over 30; k* was 8. We will continue to use this convention below; we shall also try to choose mnemonic letters to symbolize each category. Nevertheless, the number of categories that will emerge as we investigate the ramifications of the strategy space will prove to be quite daunting.

In addition, we will often be interested in the sums of numbers present in two or more categories. We will always use an upper-case K with a subscript to denote a sum of variables; similarly, upper-case K* with a subscript will denote a sum of outcomes. The subscript on the symbol distinguishes it from other sums, and also serves as a mnemonic device. For example, K_W

[10] We used the term "aftermarket" in DR1, and we shall use it consistently throughout these papers. In effect, "the aftermarket of designs" abstracts from a full-fledged specification of a product market those elements most directly affect *ex ante* assessments of value and sufficiency by would-be monopolists and entrants. In this sense, the aftermarket specification is a "summary representation"that supports the "institution" of monopoly. (On summary representations, see Aoki, 2001.)

is a sum that is of interest in the presence of "winner-take-all" beliefs; K_A is a sum that is of interest when the monopolist can acquire its rivals.

4 A Winner-Take-All Aftermarket

We shall see that the players' beliefs about aftermarket competition are crucial to the outcomes and the equilibria of all of our games.[11] As the first scenario, let us suppose that the monopolist and all potential entrants believe that the aftermarket for design solutions will be "winner-take-all." That is, they believe that when the uncertainty about design quality is resolved, the highest ranking design (the one having highest x and therefore v), will capture the whole market, and all the other candidate designs will disappear. In addition, we assume that entrants and monopolist alike believe that any designer is as likely as any other to achieve the highest ranked solution.[12]

Consistent with previous notation, let k* denote the number of designers hired by the monopolist under first-best conditions. Let e denote the number of entrants over and above k*. (Note that k* is a number while e is a variable.) Under the beliefs specified above, a potential entrant's *ex ante* net financial value is captured by the following expression:

$$NFV_E(e; k^*) = \frac{NQ(k^*+e)}{k^* + e} - \omega T - A_E T - B_E \qquad (3)$$

The first term is simply the value of the winner-take-all market times an entrant's probability of winning. The second term is the cost of employing one designer for the contract interval. The third and fourth terms are the per-period and sunk transactions costs of the entrant: note that these do not have to be the same as the corresponding costs of the monopoly.

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[11] As we are using the term, the "institution" of monopoly includes the possibility that a monopolist-firm would not be sufficient, hence would not be found in a particular problem domain. It is looking like "Cluster" is the dual of monopoly. If that is the case, the two forms may be analytically inseparable.

[12] We are ascribing beliefs to collectives, and have to be careful about that (although "everybody" does it!). In this connection, we need to discuss the ownership and control rights of entrants vis a vis "their" inhouse designers. We also need to discuss somewhere, the non-equivalence of the BC employment contract (which may coexist with the Guild); the Monopoly employment contract; and the Entrant employment contract. They are NOT equivalent. However I think it will confuse the exposition needlessly if we introduce that fact at this juncture. Our modeling strategy, therefore, is to treat the employment contracts "as if" they were equivalent, and discuss their differences later.

Expression 3 is also the entrants' (symmetric) sufficiency constraint in a winner-take-all market. What does this mean? It means that, if potential entrants believe that the "aftermarket" has a winner-take-all structure, they can afford to enter (increasing e) until the point where Expression 3 becomes negative. Define e* as follows:

$$e^* \equiv \max \ e \text{ such that } \frac{NQ(k^*+e)}{k^*+e} - \omega T - A_E T - B_E \geq 0$$

To understand how e* gets determined, please refer back to Figure 2. In this example, the monopolist's value-maximizing k* is 8. However, if the entrants' transactions costs are less than $NQ(9)/9 - \omega T$, then at least one outsider will be sufficient and can enter. Proceeding to the right, we see that the function $NQ(k) - \omega Tk$ crosses zero at k=33. Hence if the entrants' transactions costs were zero, 25 outsiders would be sufficient and could enter. More typically, if the entrants' transactions costs are positive but less than $NQ(9)/9 - \omega T$, then e* will lie between 1 and 25.

We can capturewhat we have learned thus far in the following proposition:

Proposition 1. Let a would-be monopolist contemplate setting up a design monopoly as a first mover in a particular technological domain, with expected revenue function NQ(k). There are an unlimited number of designers who are capable of solving problems in this domain: each can be hired for a wage ω over a contract interval T. In this domain, the would-be monopolist faces transactions costs $A_M T+B_M$: potential entrants face transactions costs $A_E T+B_E$. All parameters and the Q(k) function are known to the monopolist and to potential entrants. Finally, potential entrants and the would-be monopolist believe that the "aftermarket" will have a winner-take-all structure.

(a) Under the winner-take-all belief structure, the equilibrium number of designers employed in this domain is $K_W^* = k^*+e^*$, where k* and e* are endogenously defined as follows:

$$k^* \equiv \min \ k \text{ such that } N[Q(k+1) - Q(k)] - \omega T \leq 0 \quad \text{; and}$$

$$e^* \equiv \max \ e \text{ such that } \frac{NQ(k^*+e)}{k^*+e} - \omega T - A_E T - B_E \geq 0 \ .$$

(b) Given (a), if the monopolist moves first and chooses to enter, its value-maximizing strategy is to employ K_W* designers; in this case, the potential entrants' best response is not to enter. This pair of strategies constitutes a Nash equilibrium under winner-take-all beliefs.

(c) Given (a) and (b), the *ex ante* net financial value of the monopoly in equilibrium under winner-take-all beliefs is:

$$NFV_M(K_W^*) = NQ(K_W^*) - \omega T\, K_W^* - A_M T - B_M \quad . \qquad (4)$$

This NFV is less than the first-best value of the monopolist, which sets k = k*.

(d) The NFV defined by Expression (4) will be less than zero. This will occur if the monopolist's transactions costs are sufficiently greater than the entrants' total transaction costs:

$$(A_E T + B_E)\, K_W^* \le NQ(K_W^*) - \omega T\, K_W^* < A_M T + B_M \quad ,$$

If Expression (4) is negative, the equilibrium number of designers will remain the same, but the equilibrium institutional form will be a *cluster* of K_W* separate firms.

Proof:

(a) We have already worked through the rationale that leads k*+ e* designers to be employed in the domain. If the number employed is less than k*+ e*, then potential entrants will be financially sufficient, and can enter the domain with an expectation of profit.

(b) Once K_W* is determined, the monopolist's only choice is whether to employ all, or only a fraction of, those designers. By assumption, the monopoly moves first. Therefore, it wants to determine the fraction, $0 \le \alpha \le 1$ that maximizes its net financial value:

$$\max_{\alpha} \; NFV_M(\alpha; K_W^*) = \alpha\,[NQ(K_W^*) - \omega T\, K_W^*] - A_M T - B_M \quad ; \qquad (5)$$

Clearly, $\alpha = 1$ maximizes the expression as long as the term in brackets is zero or positive.[13] But, from part (a), we know that:

$$\frac{NQ(K_W^*)}{K_W^*} - \omega T - A_E T - B_E \ge 0 \quad .$$

[13] If the term in brackets is zero, then any α maximizes the expression.

Multiplying through by K_W^* obtains:

$$[NQ(K_W^*) - \omega T K_W^*] - A_E T K_W^* - B_E K_W^* \geq 0 \quad ,$$

as an implication. Hence as long as transactions costs A_E and B_E are positive or zero (as they must be by definition), the bracketed term must be positive or zero. Therefore the monopolist, faced with the threat/reality of entry, should choose $\alpha = 1$, and employ all the designers who can profitably work in the domain.

If the monopolist employs K_W^* designers, then, by definition, additional entry is not profitable. Thus any entrant's best response to this strategy is not to enter. It follows immediately that the strategy configuration $<K_W^*, 0, \ldots, 0>$ is a Nash equilibrium. Here the first element denotes the monopolist's action, and the rest of the elements denote the entrants' actions. This equilibrium is unique if the monopolist moves first and chooses to enter.[14]

(c) The result follows immediately from setting $\alpha=1$ in Expression 5. In part (b), we showed that $\alpha = 1$ characterizes the (unique) Nash equilibrium in the game between monopolist and entrants if the monopolist moves first and chooses to enter. Since the monopolist is constrained by the threat of entry, $NFV_M(K_W^*)$ must be less than the monopolist's first best $NFV_M(k^*)$.

(d) In the definition of e* in part (a), we can substitute K_W^* for k*+e* and rearrange terms to obtain:

$$(A_E T + B_E)K_W^* \leq NQ(K_W^*) - \omega T K_W^*$$

This inequality necessarily holds in equilibrium. However, it is possible that:

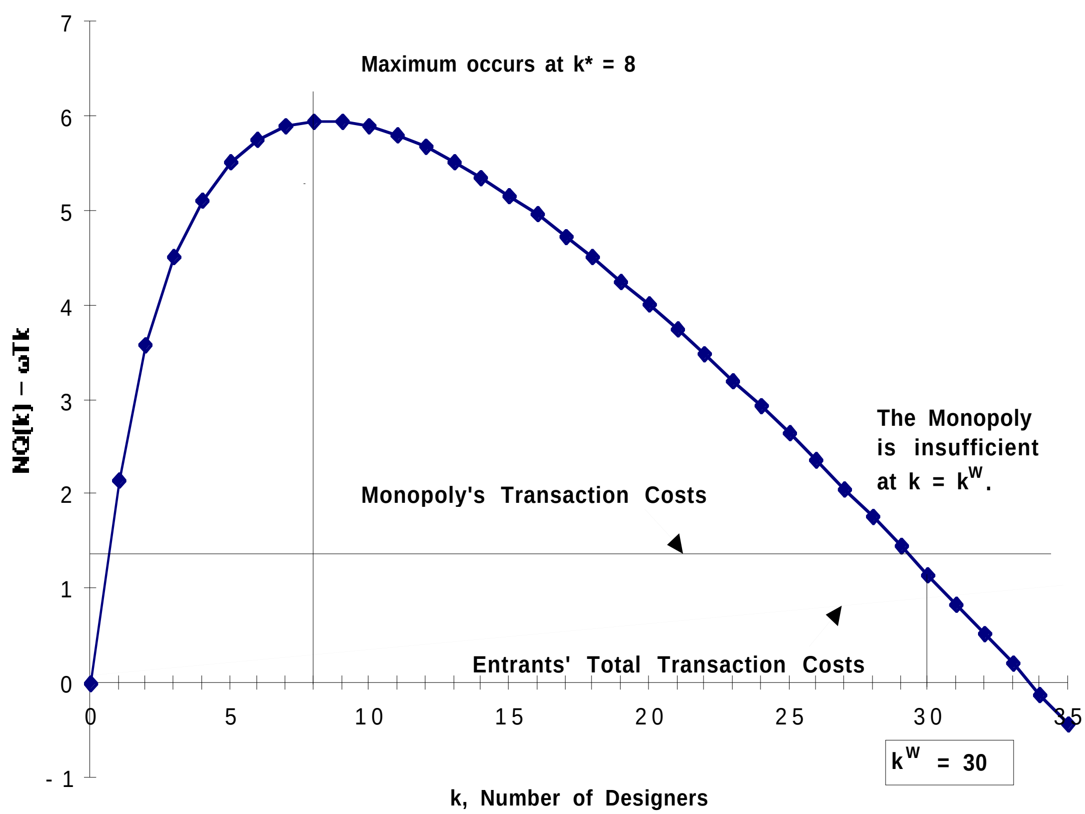
$$NQ(K_W^*) - \omega T K_W^* < A_M T + B_M \quad ;$$

If so, the transactions costs of the monopoly will be higher than the expected revenue from the monopoly in equilibrium. In this case, by definition, the monopoly is not sufficient, and it will not

[14] If the entrants move first, then a "cluster" pre-exists the monopolist. Technically, then, within the restricted terms of Proposition 1, there may be multiple equilibria. However, a pre-existing cluster raises other questions. Specifically, can the monopolist acquire pre-existing entrants? When and how? These questions are better addressed after we have introduced M&A transactions into our model world. See Section 5 below.

pay the monopolist to make the first move! This possibility is depicted in Figure 4. **[Explain Figure.]** However, the potential entrants will be sufficient, hence by the rules of the model world, they will enter and come into existence. The resulting institutional form will be a cluster of K_W* firms. **QED.**

Figure 4
An Insufficient Monopoly Under Winner-Take-All Beliefs



Clearly, becoming a design monopoly is harder than it first appears! However, a would-be monopolist has ways of enhancing its own value. In the next two sections (5 and 6), we will consider the possibility of changing the entrants' winner-take-all beliefs. After that, we will consider the possibility of pre-emptively employing qualified designers and directing their work.

5 A Monopolist-Stays-In Aftermarket

In this section, we will explore the possibility that a monopolist can use aftermarket competition as a means of enriching and sustaining a design monopoly. Designs are non-exclusive information goods, thus it is socially efficient to utilize the best available design in all appropriate contexts. However, as we have set it up, the search for new designs will also deliver solutions that are not best-in-class, but may be better than the textbook solution. Winner-take-all conditions in the aftermarket require that the inferior solutions disappear: then and only then, can the owner of the winning design charge users up to their full willingness to pay.[15]

If the monopoly "wins" a particular design tournament, then it is in that firm's interest to suppress all the inferior designs that it owns. Furthermore, a monopolist with a superior design *ex post* can always price its products so as to make inferior designs unprofitable. Thus an entrant with an inferior design that stays in the aftermarket would be foolhardy, or, in our terminology, "insufficient." However, if an entrant were to win a design tournament, a monopolist seeking to maintain its franchise might elect to stay in the aftermarket and use its own best design to "punish" the entrant. And if the threat of aftermarket competition had a large enough (negative) effect on the entrants' expected payoffs, that in turn might deter entrants from coming in initially.

Let us explore these possibilities from the monopolist's point of view. For simplicity, we assume that both the entrant and the monopoly have the same marginal costs in the aftermarket: without loss of generality, these can be set equal to zero. For the sake of argument, suppose that $e^*>1$, but the market is supply constrained: there are only k^*+1 designers in the whole world. Suppose further that the monopolist employs only k^* designers, consistent with its first-best choice. By Proposition 1, under winner-take-all beliefs, the monopolist should hire that last, lonely designer. But is this really so?

[15] Note: The textbook solution does not have to disappear, but it must cost users something to gain access to it. As long as the wage of a qualified designer, ω, is close to the value of the textbook solution, w, this condition will be satisfied. See Institutional Forms, Part 1: The Technology of Design and its Problems.

Alternatively, let us suppose that, instead of leaving the aftermarket when its own design proves to be inferior, the monopoly can credibly promise to stay and price its own best design at marginal cost. In the winner-take-all scenario, the first entrant's expected reward was:

$$\frac{NQ(k^*+1)}{k^* + 1} - \omega T - A_E T - B_E \quad .$$

(This follows from Expression 3, setting e = 1.) However, if the monopolist stays in and adopts marginal-cost pricing, then the first entrant's expected payoff drops to:

$$\frac{N[Q(k^*+1) - Q(k^*)]}{k^* + 1} - \omega T - A_E T - B_E \quad .$$

This latter amount is not only significantly less than the winner-take-all expected payoff: it is guaranteed to be negative! (This follows from the fact that $N[Q(k^*+1) - Q(k^*)] - \omega T \leq 0$ by the definition of k^*.)

This result can be generalized to apply to any number of potential entrants:

Proposition 2. Let technology and costs be as defined in Proposition 1 but for one fact: the potential entrants believe that if the monopolist's best design is inferior to an entrant's design, the monopolist will introduce its own best design in the aftermarket, and charge marginal cost (=0) for it. Entrants believe that other entrants with inferior designs will drop out as before. However, because of the monopolist's threat to remain, entrants believe that the aftermarket will not be winner-take-all. Under this belief structure, entry is not profitable, entrants will not be *ex ante* sufficient, and no entry will occur.

Proof.

As before, let e denote the number of entrants. If the monopolist stays in the aftermarket, then the expected payoff to each potential entrant is:

$$\text{Entrant's Expected Payoff} = \frac{N[Q(k^*+e) - Q(k^*)]}{k^* + e} - \omega T - A_E T - B_E \quad .$$

The first term represents an entrant's expected reward (in competition with the monopolist) times its probability of winning; the other terms represent the entrant's design and transactions costs. If the expression is greater than zero, all entrants will have reason to enter; conversely, if it is less than or equal to zero, no entrants will have reason to enter.

To begin with, we know that:

$$N[Q(k^*+1) - Q(k^*)] - \omega T \leq 0 \qquad \text{and} \qquad [Q(k^*+2) - Q(k^*+1)] < [Q(k^*+1) - Q(k^*)] \quad .$$

The first expression follows from the definition of k*; the second from the fact that Q(k) is concave. Combining these two expressions, it follows that:

$$N[Q(k^*+e) - Q(k^*)] - \omega Te < 0 \quad ,$$

hence, *a fortiori*:

$$N[Q(k^*+e) - Q(k^*)] - \omega T(k^*+ e) - A_E T(k^*+ e) - B_E(k^*+ e) < 0 \quad .$$

Dividing both sides by k*+ x, obtains:

$$\frac{N[Q(k^*+e) - Q(k^*)]}{k^* + e} - \omega T - A_E T - B_E < 0 \quad ;$$

which is to say that each entrant's expected payoff is less than zero. Hence all entrants will be *ex ante* insufficient, and by the rules of our model world, will not enter. **QED**

Propositions 1 and 2 illustrate a principle put forward by John Sutton in *Sunk Costs and Market Structure*: He observes that, in a two-stage game of entry followed by product market competition, "tougher competition in the post-entry stage of the game makes the entry of rival producers less attractive."[16] Winner-take-all is favorable regime in the aftermarket, hence it should attract lots of entry; Monopolist-stays-in is an unfavorable regime, hence, we have just shown, it should attract no entry.

[16] Sutton, 1991, p. 41.

Thus, to have sustainable monopoly with first-best profitability (k=k*), the monopolist only has to convince potential entrants that it will stay in the aftermarket with its own best design. That particular system of beliefs can turn the monopoly into an Aoki-style institution. In this setting, the monopoly will hire k* designers,[17] and its net financial value will be first-best:

$$NFV_M(k^*) = N\,Q(k^*) - \omega T k^* - A_M T - B_M > 0 \quad .$$

Note that the local system we have just specified, consisting of:

- the Q(k) substrate;
- the monopolist;
- the k* designers employed by the monopolist;
- the outside designers and the potential entrants; and
- the belief-generating institution,

is in equilibrium regardless how many designers are qualified to work in the monopolist's problem domain. The monopolist only has to hire the k* designers that it wants to put to work: the rest will not be able to obtain the financial resources necessary for entry, and must find other employment.

Clearly, however, the potential entrants' beliefs are critical to maintaining the equilibrium of the local system. However, the beliefs needed to sustain the monopoly is problematic on two grounds. First, in the following, we shall argue that, in the presence of mergers and acquisitions (M&A), the monopolist's strategy of remaining in the aftermarket is not subgame perfect. Hence, the putative entrants may find the monopolist's threat not credible: they may enter the design stage in the expectation that the entrant with the best design will be bought by the monopolist.

Later on, we shall consider the belief formation process itself. The outcomes of Q(k) processes are fundamentally noisy, hence entrants can easily mis-estimate their expected payoffs. This in turn means that, in order to sustain its monopoly, the monopolist must deter not only "smart" entrants, but "dumb" ones as well.

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[17] Sequential strategies may be even more profitable, in which case the monopolist would hire fewer designers and have an even higher NFV!

6 Mergers & Acquisitions

Absent a market for mergers and acquisitions, or M&A for short, the monopolist's entry-deterring threat, to enter (or stay in) the aftermarket with its own best design priced at marginal cost, should be quite credible. The monopolist, after all, will have a design that (in expectations) is better than the textbook solution. It simply needs to price the product that embodies its solution so that "the aftermarket project" obtains an NPV=0.[18] Then, in a one-shot game, the monopolist should be credibly indifferent between coming in or staying out of the aftermarket.[19]

However, in the presence of an M&A market, the monopolist's threat is not "renegotiation-proof." After the fact, both the defending monopolist and the successful entrant will benefit if they can arrange to take the inferior design off the market as soon as possible, and begin charging users their full willingness-to-pay. The *ex post* value created by such a move is simply the difference between the *ex post* value of payoffs with and without the inferior design:

$$\begin{aligned} \text{Value created} &= \text{Value (Winner-Take-All)} - \text{Value (Monopolist-Stays-In)} \\ &= NQ^*(k^*+e) - N[Q^*(k^*+e) - Q^*(k^*)] \\ &= NQ^*(k^*) \quad . \end{aligned}$$

Here, $Q^*(.)$ denotes a particular realization of a $Q(.)$-type distribution. This value can be split in *ex post* negotiations between the monopolist and the winner. The fraction obtained by each party is a function of their bargaining power. Let γ denote the fraction which the monopolist expects to obtain *ex ante*, and let $(1-\gamma)$ denote the fraction expected to go to the winning entrant. For now, assume that $(\gamma, 1-\gamma)$ are correctly anticipated and common knowledge to both parties. Finally assume that the monopolist initially employs k^* (the first-best number of) designers.

With the possibility of being acquired factored in, each potential entrant's new expected payoff is:

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[18] "The aftermarket project" includes all the things that must be done to turn the best design into one or more saleable products. These include things like manufacturing, packaging and distribution.

[19] Technically, there is the possibility of a "war of attrition" between the entrant with the best design and the monopolist. But remember the point is entry deterrence. The prospect of a war of attrition is as chilling to most entrants as having to share the market!

$$\text{Entrant's Expected Payoff} = \frac{N[Q(k^*+e) - \gamma Q(k^*)]}{k^* + e} - \omega T - A_E T - B_E \quad . \qquad (6)$$

In this expression, if γ=1, the entrant's expected payoff is equivalent to that in the "monopolist-stays-in" scenario; if γ=0, it is the same as in the "winner-take-all" scenario. And by continuity, values of γ between 0 and 1 obtain expected payoffs between those two extremes. This in turn means that an equilibrium with any number of entrants between 0 and e* (defined in Proposition 1) can be supported by some common-knowledge belief about (γ, 1–γ), the relative bargaining power and *ex post* value split between the two parties.

However, we are also in a Grossman-Hart world. If the parties anticipate that they will be negotiating after the fact, then it is rational for them to invest *ex ante* in order to improve their *ex post* bargaining positions. In particular, Expression 6 shows that if $\gamma > 0$ and the monopolist employs *more than* k* designers, the entrants' expected payoffs will decline. In that case, the equilibrium number of entrants should decline as well. Thus a strategy of employing more than k* designers *ex ante* is an effective supplement to the strategy of *ex post* acquisition.

This employment policy amounts to a strategy of *ex ante* acquisition: rather than waiting until the outside designers' searches are over, and a winner has been determined, the monopolist can incorporate the outside designers into its own establishment. Expression 5 indicates that acquiring/employing members of the "competitive fringe" of entrants is a good policy for the monopolist: each such acquisition reduces the other potential entrants' expected payoffs and causes the equilibrium number of entrants to decline.

Still the process of *ex ante* acquisitions might be imperfect or incomplete. For one thing, entrants may be hard to find, hence too expensive for the monopolist to search out. As well, there is the potential for adverse selection: those entrants who are most willing to be bought *ex ante* might have inferior chances of success. Thus to complete our analysis of the M&A equilibrium, let us stipulate that some fraction, ϕ, of the competitive fringe of entrants cannot be acquired *ex ante*. We can then see how the equilibrium outcomes vary as the fraction ϕ ranges from 0 to 1.

6.1 Equilibrium with M&A Beliefs

In this section, we will formally characterize the equilibrium with M&A beliefs. Before we proceed, however, we need to introduce some additional notation. As before, let k* denote the number of designers that the monopolist would like to hire in the first-best scenario. Let x denote the number of "extra" designers that the monopolist acquires or employs *ex ante* in order to deter entry; and let f denote the number of entrants remaining in the fringe. By definition:

$$f/(x+f) \equiv \phi \in [0, 1] \quad .$$

Define K_A as the total number of designers employed in the domain:

$$K_A = k^* + x + f \quad .$$

Finally define the "acquisition surplus," as the expected value created via the *ex post* acquisition of a winning entrant by the monopolist, and the withdrawal of the second-best design from the market. By the same argument as as above, it is easy to show that:

$$\text{Acquisition Surplus} = NQ(k^*+x) \quad . \tag{7}$$

Because $k^*+x \geq k^*$ for $x \geq 0$, the Acquisition Surplus declines as x increases.

The full equilibrium with M&A beliefs can now be captured in the following proposition:

Proposition 3. Let technology and costs be as defined in Propositions 1 and 2. Further assume that potential entrants and the monopolist believe that, if an entrant wins the design competition, the winning entrant will be acquired by the monopolist, and the surplus created by the acquisition (defined below) will be split with γ going to the monopolist and $1-\gamma$ going to the winning entrant. Finally assume that all parties believe there is a "fringe", that is, a fraction, ϕ, of potential entrants in excess of k* that cannot be acquired before the results of their searches are known. Call this set of common beliefs "the M&A belief structure."

(a) Under the M&A belief structure, the equilibrium number of designers employed in this domain is $K_A^* = k^*+x^*+f^*$. These quantities are endogenously defined as follows: First, from Proposition 1:

$$k^* \equiv \min \ k \text{ such that } N[Q(k+1) - Q(k)] - \omega T \leq 0 \quad \text{; and}$$

$$e^* \equiv \max \ e \text{ such that } \frac{NQ(k^*+e)}{k^*+e} - \omega T - A_E T - B_E \geq 0 \quad .$$

If $\phi < (e^*-1)/e^*$, then

$$f \equiv \text{the integer part of } x\phi/(1-\phi) \text{ ; and}$$

$$x^* \equiv \max x \text{ such that } \frac{N[Q(k^*+x+f) - \gamma Q(k^*+x)]}{k^*+x+f} - \omega T - A_E T - B_E \geq 0 \text{ , and}$$

If $\phi \geq (e^*-1)/e^*$, then, $x^*=0$ and $f^* = e^*$ as defined above. (The complicated bounds on the definitions arise because, although Q(.) can be analyzed as a continuous function of its argument, the actual x and f obtained in equilibrium must be integers.)[20]

(b) Given (a), the monopolist's value-maximizing strategy is to employ k^*+x^* designers; in this case, f^* other firms will enter. These strategies constitutes a Nash equilibrium under M&A beliefs.

(c) Given (a) and (b), the *ex ante* net financial value of the monopoly in equilibrium under M&A beliefs is:

$$NFV_M(x; k^*, \gamma, \phi) = \frac{(k^*+x^*)NQ(K_A^*)}{K_A^*} + \frac{f^*\gamma NQ(k^*+x^*)}{K_A^*} - \omega T(k^*+x^*) - A_M T - B_M \ .$$

The first term in this expression is the expected payoff to the monopolist if it wins the design competition times the probability of winning. The second term is the payoff to the monopolist if a fringe entrant wins and is acquired times the probability of this happening. The last three terms represent the monopolist's costs. This NFV is less than the first-best value of the monopolist, which sets total $k = k^*$.

(d) Under the M&A belief structure, the equilibrium number of designers employed in excess of k^* lies between 0 and e^* (defined above and in Proposition 1). This number and its two elements, x^* and f^*, decline with γ, the monopolist's share of the M&A surplus, and increase with ϕ, the relative size of the fringe.

Proof.

See the Appendix. (Note: Some parts of the proof are intricate, but the logic is relatively straightforward. It follows the same pattern as the proof of Proposition 1.)

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[20] We have to worry a little about the fact that x and f are integers, although our analysis is going to "pretend" that they are continuous implicit functions. I don't think this makes a big difference, except in terms of mathematical elegance. The equilibria will go to the nearest integer values, and changes will take place in steps.

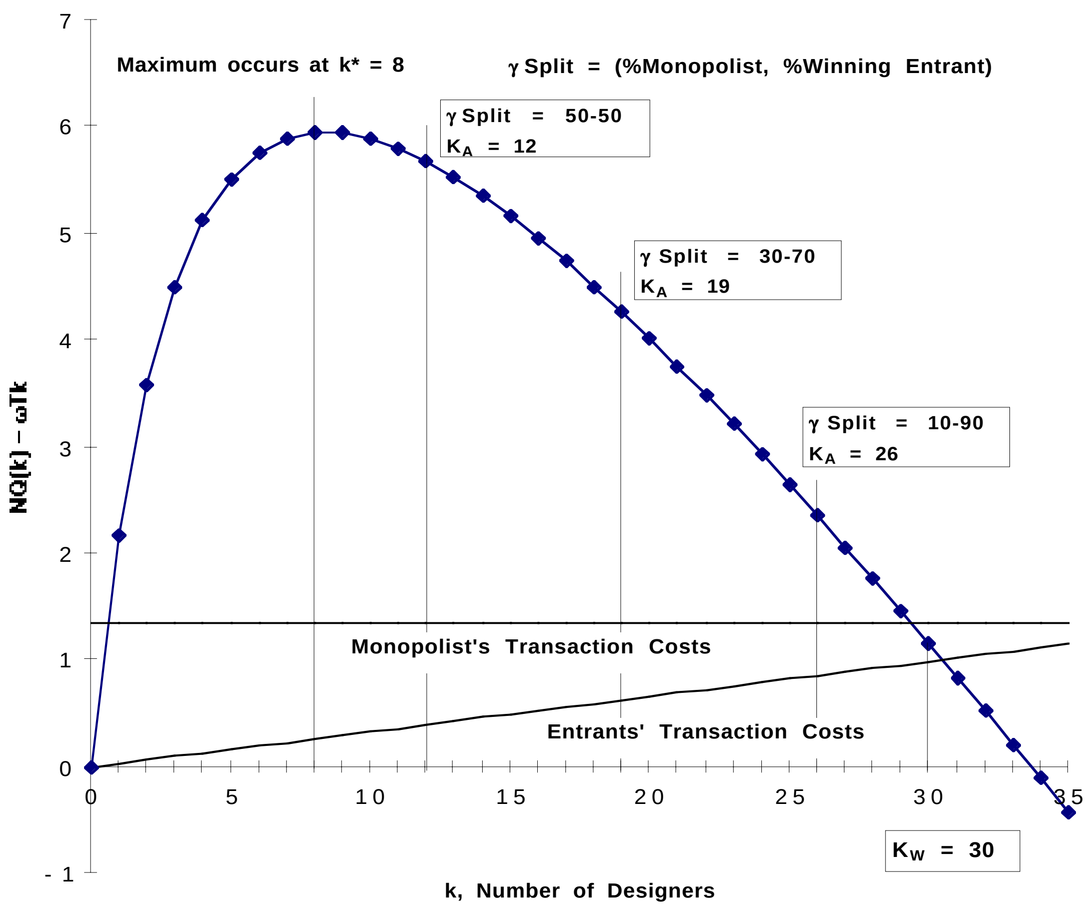
6.2 A Numerical Example

M&A beliefs generate a family of equilibria: one for each possible combination of γ and ϕ. We can show how these equilibria are related to one another and to the Winner-Take-All and Monopoly-Stays-In equilibria via a numerical example. To fix ideas, let us continue to use the Q(k) function depicted in Figures 3 and 4 above. Figure 5 starts with that function and associated transactions costs. In it, we assume that there is no competitive fringe ($\phi = 0$), and calculate K_A* for different values of γ. Recall that $\gamma = 0$ means that the monopolist gets nothing if an entrant wins the design competition. This is equivalent to the Winner-Take-All equilibrium described in Proposition 1. Conversely, if γ=1, then all the value is captured by the monopolist: this is equivalent to the Monopolist-Stays-In equilibrium described in Proposition 2 above.

In the figure, we show K_A for γs equal to 50%, 30% and 10%. For example, if γ = 50%, implying that the monopolist and the winning entrant split the acquisition surplus 50-50, then the monopolist needs to hire twelve designers, instead of the first-best eight, in order to deter additional entry. The four "extra" designers serve two roles. First, as we showed in Proposition 1, if these designers are going work in the domain anyway, then it is profitable for the monopolist to hire them: ignoring their effect on the other projects, their expected revenue is greater than their direct cost. Second, hiring these designers reduces the acquisition surplus (see Expression 7), which, in turn reduces potential entrants' incentives to enter.

As the value of γ declines, potential winning entrants can expect to capture more and more of the acquisition surplus. Not surprisingly, K_A* the equilibrium number of designers employed in the domain, goes up commensurately. The figure shows that if 30% of the value goes to the monopolist and 70% to the winning entrant, K_A* increases to 19; if only 10% goes to the monopolist, then K_A* is 26.

Figure 5
Equilibrium with M&A Beliefs
Variable Bargaining Power; No Competitive Fringe



Even with 26 designers employed, however, the monopolist is still sufficient: this can be seen by comparing the height of the inverted "U" function to the line representing the monopolist's transactions cost. However, if γ falls to zero, so that the entrants expect to capture *all* the acquisition surplus, the entry-deterring number of designers will be 30. At this level, the monopolist is insufficient, and the equilibrium institutional form will be a cluster.

Now let us fix γ, and consider the effects of varying the relative size of the competitive fringe. Recall that the "fringe" was parametrized by ϕ, defined as the percentage of outside designers who cannot be hired or acquired *ex ante*, However, a fringe member who wins the design tournament can be acquired *ex post*, in return for 1– γ of the value created by the acquisition. (The *ex post* acquisition takes the second-best design off the market, hence the deal is in the interests of both the monopolist and the winning entrant.)

Figure 6 plots K_A*, x* and f* for various values of ϕ, holding γ fixed at 50% in all calculations. If $\phi = 0$, $K_A^* = 12$, and all of these designers are employed by the monopolist. this corresponds to the 50-50 split in Figure 5. As ϕ increases to 60%, K_A* increases to 13, although the number of designers employed by the monopolist drops to $k^*+x^* = 10$. The remaining three designers will work for entrants in the fringe: those firms will enter expecting to be acquired and to claim 50% of the acquisition surplus, if they win the design tournament. Finally if ϕ increases to 100%, K_A increases to 15. Eight of the fifteen designers will work for the monopolist, while the remaining seven will work for entrants in the fringe.

In Figure 6, the total number of designers employed in equilibrium, K_A*, increases as the relative size of the fringe increases. The reason is that the larger the fringe, the lower is the expected quality of the monopolist's "second-best" design. As a result, the expected acquisition surplus will be higher (see Expression 7), and the incentives to enter will be greater. Hence K_A* increases with ϕ.

Notice, however, that for fixed γ, the values of K_A* are quite narrowly bounded: over the full range of ϕ, K_A* only ranges from 12 to 15. In contrast, we saw in Figure 5, that over the full range of γ, K_A* spanned a range from 8 to 30. This result generalizes: for a fixed ϕ, varying γ causes K_A* to vary over its whole range (from k* to k*+e*), whereas for fixed γ, varying ϕ causes K_A* to change only a little bit, or not at all.

Figure 6
Equilibrium with M&A Beliefs
Fixed Bargaining Power; Variable Competitive Fringe

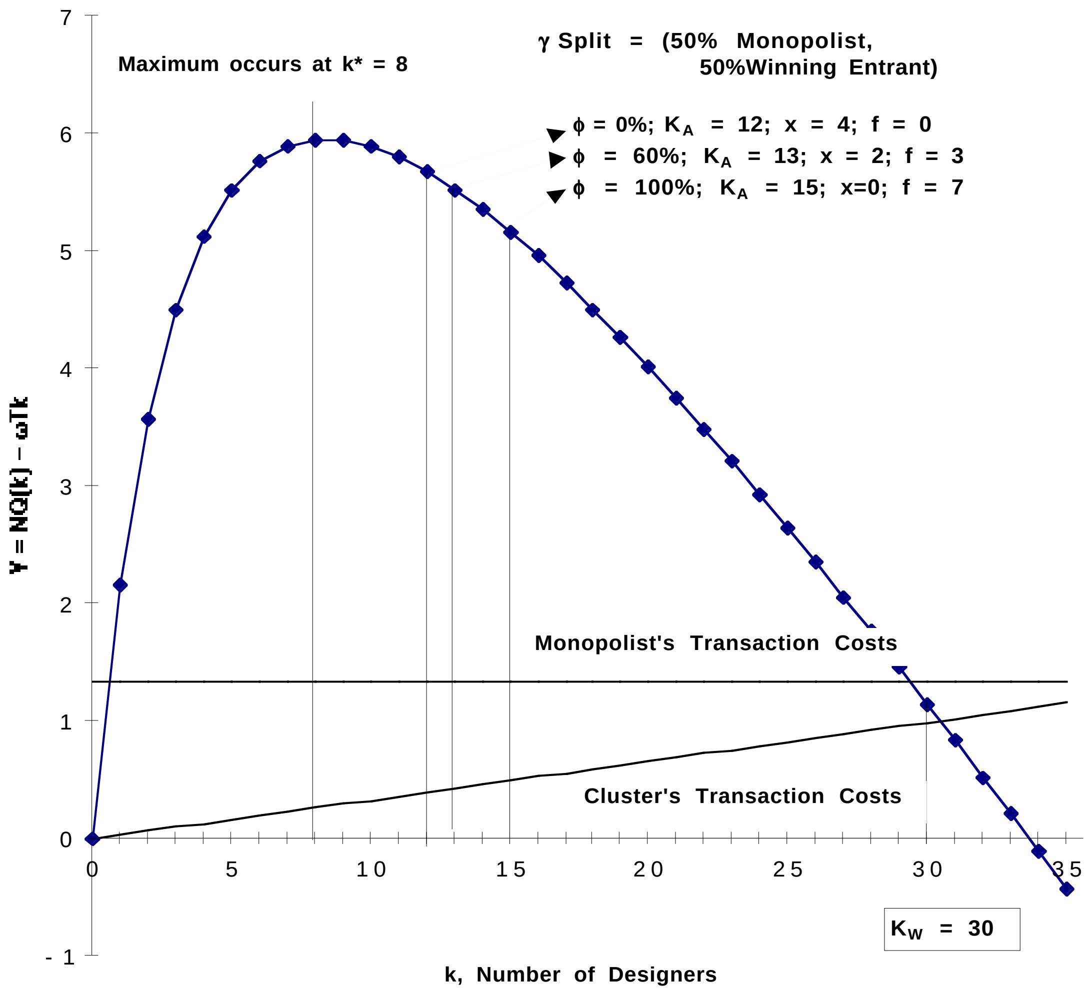


Table 1 shows the value of the monopolist as a percent of the "first-best" value for different values of γ and ϕ. The transactions costs and Q(k) assumptions are the same as we have been using all along. The table shows that for almost all γs greater than 50%, the monopolist can deter entry and achieve 100% of its first-best value. However, as γ falls to 50% or below, the entrants' incentives to enter increase. Then the monopolist must either (1) hire designers to "crowd out" entrants (if ϕ is low); or (2) anticipate and plan for entry (if ϕ is high). In either case, the value of the monopoly declines: as we have already explained, it declines by more as the relative size of the fringe increases.

Table 1
Value of the Monopolist as a Percent of "First-best" Value

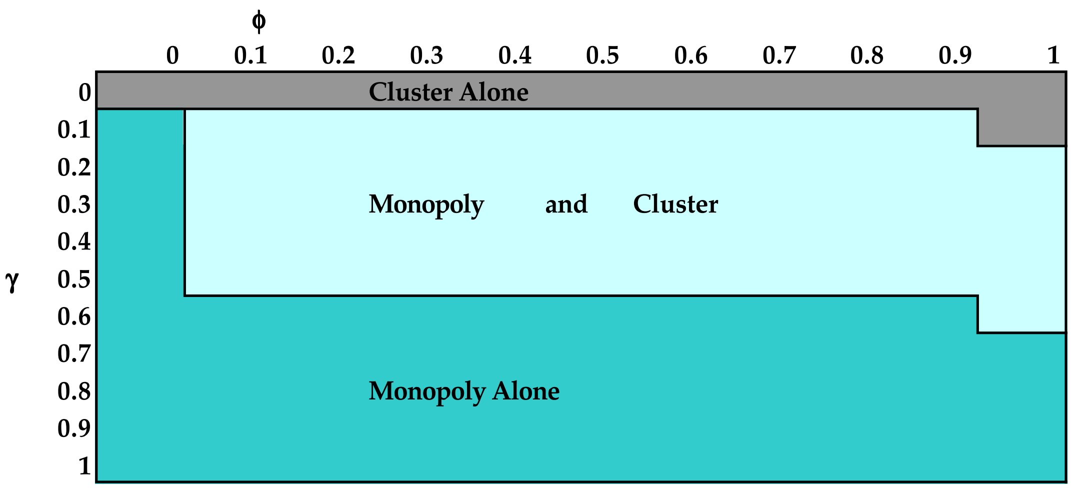
			ϕ									
		0	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1**
	0	-4%	-6%	-7%	-9%	-11%	-13%	-15%	-17%	-18%	-20%	-22%
	0.1	22%	21%	19%	17%	15%	9%	7%	6%	3%	1%	-2%
	0.2	47%	40%	38%	37%	35%	34%	32%	31%	25%	22%	19%
	0.3	63%	63%	62%	60%	59%	53%	52%	50%	45%	43%	36%
	0.4	83%	83%	82%	77%	76%	74%	74%	69%	67%	61%	58%
γ	**0.5**	94%	94%	94%	93%	89%	89%	88%	88%	86%	82%	77%
	0.6	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	97%
	0.7	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	0.8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	0.9	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

The table also shows that for very low γs (e.g., below .1), the value of the monopolist is less than zero across a range of ϕs. This indicates that the monopolist is *insufficient* for these parameter values. At these values of γ and ϕ, its expected revenue in equilibrium is less than its transactions costs.

In this example, the monopolist is insufficient in equilibrium for some γ, ϕ combinations because we initially assumed that the entrants' aggregate transactions costs were less than the monopolist's for values of k less than $K_W = 30$ (see Figure 4). Hence, entrants as a group are more efficient than the monopolist over the relevant range of k. When this occurs, there may be so much entry anticipated to take place in equilibrium, that a would-be monopolist, looking forward in Stage 1a of the game, will conclude that it does not pay to enter at all! A cluster *sans* monopolist will be the dominant institutional form (in that Q(k) domain).

Table 1 can thus be redrawn as a "map" of where in the parameter space of γ and ϕ different institutional forms will be found (see Figure 7 for such a map). Note that a similar belief structure (the M&A belief system) varying on only two dimensions (γ and ϕ) yields the whole range of institutional outcomes, from Cluster alone, to Monopoly and Cluster, to Monopoly alone. This map highlights the fact that the design monopoly and the cluster are complementary institutional forms: even if only one form is observed in reality, the other exists as a possibility that may be constraining the equilibrium through the beliefs of the would-be monopolist or the potential entrants.

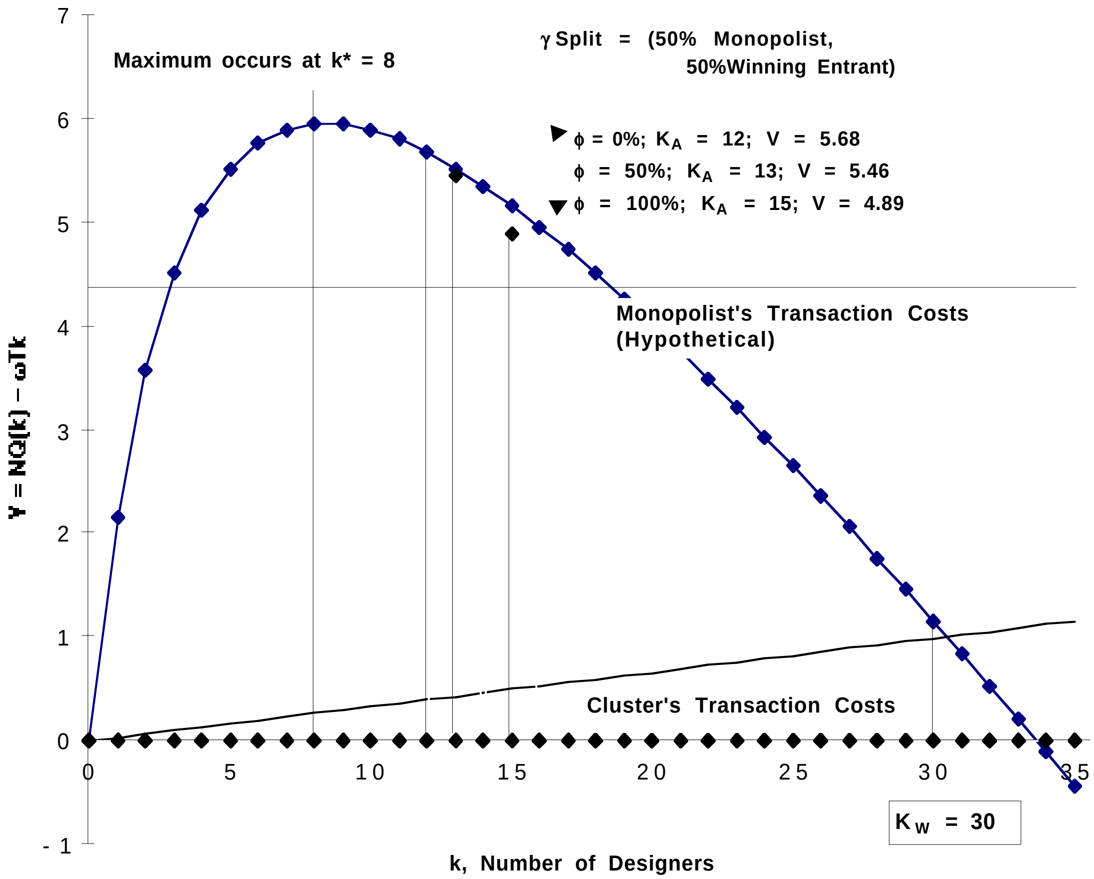
Figure 7
A "Map" of Institutional Forms Observed in the Parameter Space of γ and ϕ



6.3 The Pac-Man Strategy and Equilibrium (Save for Later)

Figures 5 and 6 together suggest an interesting possibility: a monopoly that can do M&A transactions may be able to achieve equilibrium even if it is not as efficient as the corresponding Cluster. We call this the "Pac-Man" strategy and equilibrium because the monopolist basically wants to "gobble up" entrants *ex ante* (if possible) or *ex post* (if necessary) This strategy can work as long as the monopolist's bargaining power, γ, is sufficiently high. Figure 8 shows how.

Figure 8
A "Pac-Man" Equilibrium



7 Conclusion

Under the institutional regimes derived above, the basic problems of communication (pooling) and coordination (task assignment) will be solved. Designers will work in a given Q(k) domain as a result of being employed by a monopolist or an entrant and assigned to the domain. The number of designers working in a given domain will be between k* and k*+e*, values that are economically sensible. When they learn of the existence of the monopoly-cluster, designers at user-firms (under the assumptions of our model) will stop working on these problems, and turn their efforts to solving others. And , *ex post*, in equilibrium, the best solution will be used everywhere. (The Monopoly-Stays-In outcome is "off the equilibrium path.")

Thus, measured against the Base Case and the "generic problems of the substrate," the Monopoly-Cluster family of institutions does pretty well. But the family also has some interesting (disturbing?) features. First, in the presence of an M&A market and supporting belief system, the most efficient institutional form does not necessarily become the dominant form. Second, as we have set it up, the cluster is very turbulent. (This might or might not be a problem, but it is worth noting.)

Third, the actual equilibrium, hence actions and investments in Stage 1 are based the players' beliefs. For these beliefs to be rational it must be true that the actual payoffs are probabilistically consistent with the anticipated payoffs, which caused the investment behavior, which in turn generated the probabilisitic payoffs. If this sounds circular, that is because it is! But such consistency is very hard, maybe impossible, to arrive at given reasonable assumptions about the observational capacity and search costs of the agents. (This is not self-evident: we need to show it!)

We should also revisit the question, What does this family of institutions "need" from the greater economy in order to come into existence? Here is a short list:

- Mechanisms of exclusion, some combination of property rights and protective technology (trade secrets).
- Employment contracts that allow an employer to direct the work of its designer-employees, with no increase in cost and no decrease in the designers' effectiveness.
- Channels of communication with user-firms. The user-firms (or their agents) need to know that they will be able to buy solutions in a particular Q(k) domain in the form of pre-packaged products, services or a combination of the two. The user-firms must also be able to assess the financial value $v(x^*)$ of a design/solution of quality x^*, so that they will willingly pay for it. Note, however, that $v(x^*)$ can be *ex post* value of a particular design. The user-firms do not need to know the function v(x) nor the derive function Q(k).
- Channels of communication with designers at the user-firms and elsewhere (for example, at school, where the designers get their specialized training). The monopolist and entrants need to be able to recruit designers. The designers at user-firms also must know to stop working in specific Q(k) domains.
- For the M&A equilibria, a market for corporate control and/or a market for intellectual property. Either will do, because the acquisition of a winning design can be structured as the sale of the design or as the sale of the company which owns the design.

Then there is another more subtle set of needs: Methods of forming/ transmitting/ inducing/ confirming beliefs!

- *Ex ante*, the monopolist and the entrants need some means of estimating N, ωT, and both the monopolist's and the entrants' transactions costs.
- They also need some way of estimating Q(k): this amounts to a technology of investment analysis and present valuation. (We often take these things for granted,

but they are "gifts" of modern finance, beginning with Graham and Dodd and carrying through to DR1.)

- Some way of knowing how many firms actually entered a given domain.
- Some way of comparing *ex post* outcomes with *ex ante* expectations.

These last two items turn out to be very hard to obtain in practice: so much so that the whole notion of an institutional equilbrium might come crashing down about us! Our next analytic task is to explain why that is so. This will take us outside the range of "normal" game-theoretic tools. It is time to reread Aoki's chapters on beliefs, and to get serious about the evolutionary game theory.

Appendix
Proof of Proposition 3

Proposition 3

For convenience, the Proposition is restated by parts:

Initial Assumptions

Let technology and costs be as defined in Propositions 1 and 2. Further assume that potential entrants and the monopolist believe that, if an entrant wins the design competition, the winning entrant will be acquired by the monopolist, and the surplus created by the acquisition (defined below) will be split with γ going to the monopolist and $1-\gamma$ going to the winning entrant. Finally assume that all parties believe there is a "fringe", that is, a fraction, ϕ, of potential entrants in excess of k* that cannot be acquired before the results of their searches are known. Call this set of common beliefs "the M&A belief structure."

Part (a)

(a) Under the M&A belief structure, the equilibrium number of designers employed in this domain is $K_A^* = k^*+x^*+f^*$. These quantities are endogenously defined as follows: First, from Proposition 1:

$$k^* \equiv \min \; k \text{ such that } N[Q(k+1) - Q(k)] - \omega T \leq 0 \quad ; \text{and}$$

$$e^* \equiv \max \; e \text{ such that } \frac{NQ(k^*+e)}{k^* + e} - \omega T - A_E T - B_E \geq 0 \; .$$

If $\phi < (e^*-1)/e^*$, then

$$f \equiv \text{the integer part of } x\phi/(1-\phi) \; ; \text{and}$$

$$x^* \equiv \max x \text{ such that } \frac{N[Q(k^*+ x + f) - \gamma Q(k^*+x)]}{k^* + x + f} - \omega T - A_E T - B_E \geq 0 \; .$$

If $\phi \geq (e^*-1)/e^*$, then, $x^*=0$ and $f^* = e^*$ as defined above. (The complicated bounds on the definitions arise because, the actual x and f obtained in equilibrium must be integers.)

Proof: If there were no threat of entry, the monopolist would like to employ k* designers. However, under M&A beliefs, for some γs greater than zero but less than one, entrants will be sufficient, hence have reason to enter. The monopolist can reduce the entrant's incentives by employing more designers (increasing x). However, we have stipulated that there is an ineradicable fringe. When x = x*, additional entrants will be insufficient, and no more entry will take place. The total number of designers employed in the domain in equilibrium under M&A beliefs is then the sum of:

- the designers employed in a first-best world, k*;
- the additional designers employed to deter entry, x*; and
- the proportional fringe, f*.

Parts (b) and (c)

(b) Given (a), the monopolist's value-maximizing strategy is to employ k*+x* designers; in this case, f* other firms will enter. These strategies constitutes a Nash equilibrium under M&A beliefs.

(c) Given (a) and (b), the *ex ante* net financial value of the monopoly in equilibrium under M&A beliefs is:

$$NFV_M(x; k^*, \gamma, \phi) = \frac{(k^*+x^*)NQ(K_A^*)}{K_A^*} + \frac{f^*\gamma\, NQ(k^*+x^*)}{K_A^*} - \omega T\,(k^*+x^*) - A_M T - B_M \ .$$

The first term in this expression is the expected payoff to the monopolist if it wins the design competition times the probability of winning. The second term is the payoff to the monopolist if a fringe entrant wins and is acquired times the probability of this happening. The last three terms represent the monopolist's costs. This NFV is less than the first-best value of the monopolist, which sets total k= k*.

Proof: The proofs of Parts (b) and (c) follow immediately from (a) and the definitions.

Part (d)

Under the M&A belief structure, the equilibrium number of designers employed in excess of k* lies between 0 and e* (defined above and in Proposition 1). This number and its two elements, x* and f*, decline with γ, the monopolist's share of the M&A surplus, and increase with ϕ, the relative size of the fringe.

Proof: Compare the entrants' expected payoff under M&A beliefs vs. Winner-Take-All beliefs and Monopolist-Stays-In beliefs. For any $\phi \in [0, 1]$ and $\gamma \in [0, 1]$, the entrant's expected payoff under M&A beliefs is less than or equal to Winner-Take-All payoffs and greater than or equal to Monopolist-Stays-In payoffs. Hence $0 \leq x^* + f^* \leq e^*$, where 0 is the equilibrium number of additional designers under Monopolist-Stays-In beliefs, and e^* is the equilibrium number of additional designers under Winner-Take-All beliefs.

Let $\phi \geq (e^*-1)/e^*$. This means that the monopolist cannot hire any "extra" designers, hence $x^*=0$. (The bound is imposed by the constraint that x and f be integers, i.e. "whole" designers.) If $\gamma = 0$, conditions for the entrants are exactly as assumed in the Winner-Take-All world: in that case, $K_A^* = k^* + e^*$, by Proposition 1. Conversely, if $\gamma = 1$, conditions are exactly as in the Monopolist-Stays-In world, and $K_A = k^*$, by Proposition 2.

Conversely let $0 \leq \phi < (e^*-1)/e^*$. In this range, the monopolist can hire at least one "extra" designer if it so chooses. For $\gamma = 0$, the payoffs to the entrants are again exactly as in the Winner-Take-All world, and $K_A^* = k^* + e^*$, by Proposition 1. However, the monopolist can now hire one or more of the potential entrants, and by Part b of Proposition 1, it will want to do so. At the other extreme value, for $\gamma = 1$, payoffs to the entrants are the same as in the Monopolist-Stays-In world. In that case, $K_A^* = k^*$, by Proposition 2, and the monopolist does not need to employ any extra designers.

We must now consider interior values of x^* and f^* corresponding to γs in the interval $0<\gamma<1$, and ϕs in the interval $0 \leq \phi < (e^*-1)/e^*$. Here we must resort to a "trick." Notice that if we assume that x and f are continuous variables (instead of integer variables), all the other functions are perfectly well-defined and continous with respect to the parameters γ and ϕ. Also, the integer values of x^* and f^* are always within the unit interval of the corresponding continuous values of x^* and f^*. Thus, viewed as functions of γ and ϕ, the integer-valued x^* and f^* must behave as step-wise approximations of the corresponding real-valued functions. Thus we will analyze the behavior of the continuous functions $x^*(\gamma, \phi)$ and $f^*(\gamma, \phi)$, and from them infer the behavior of the corresponding integer functions.

To begin with, suppose that a particular (real) number $x^*(\gamma, \phi)$ satisfies the definition of x^* for some combination of γ and ϕ. The expected payoff to an entrant then equals zero:

$$\frac{N[Q(K_A^*) - \gamma Q(k^*+x^*)]}{K_A^*} - \omega T - A_E T - B_E = 0 \qquad (A.1)$$

by the definition of x^* and continuity. If we fix K_A, and let γ increase, the left-hand-side of Expression (A.1) will decline. But then the total number of designers, K_A^*, must also decline in order to bring the system back into equilibrium. Because x and f are in fixed proportion, this decline in K_A^* will cause both x^* and f^* to go down *pari passus*.

Let us now return to the initial $x^*(\gamma, \phi)$. If we fix K_A, and let ϕ increase, x will go down and f go up commensurately, because $k^* + x + f = K_A$. Lower x implies lower $Q(k^*+x)$, hence, for fixed γ, if ϕ increases, $\gamma Q(k^*+x)$ will go down. Therefore an entrant's expected payoff, shown on the left-hand-side of Expression A.1 will *increase* with ϕ. The total number of designers, K_A^*, must then increase in order to bring the system back into equilibrium. It follows immediately that f^*, the equilibrium number of entrants in the fringe, increases with ϕ.

In addition, from the boundary conditions already proven: $x^*(0, 0) = e^*$; $x^*(1, 0) = 0$; $x^*(0, 1) = 0$; $x^*(1, 1) = 0$; and the continuity of $x^*(\gamma, \phi)$; x^*, the number of designers employed by the monopolist, must *decline* as ϕ goes up.

We have already said that the integer $x^*(\gamma, \phi)$ and $f^*(\gamma, \phi)$ can be viewed as step-wise approximations of their continuous analogues. Indeed, at those points where the continuous functions assume integer values (as they must by continuity), the functions will be identical. Those integer values define a "lattice" in the (continous) parameter space of γ and ϕ. For changes greater than one "step" in the lattice, the integer functions will behave like the corresponding continuous functions with respect to changes in γ and ϕ. For changes less than one "step" in the lattice, the integer functions will be flat with respect to changes in γ and ϕ. **QED**

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