Competing for a Quiet Life: An Organizational Theory of Market Structure*

Patrick Legros[†] Andrew Newman[‡] Zsolt Udvari[§]

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Abstract

We develop a property-rights model of endogenous market structure in which contracting imperfections, rather than scale economies, emerge as the source of market power. Production of a homogenous good is carried out by substitutable, incentive-constrained teams that can stand alone as perfect competitors or sell their assets to profit-motivated HQs, thereby becoming subordinate members of their firms. HQs subsequently Cournot compete in the product market. Team output and costs aggregate linearly within and across firms, there are no diseconomies of HQ ownership, and HQs are abundant.

A fundamental "hold-out" problem places lower and upper bounds on the degree of concentration. The equilibrium market structure is typically an oligopoly, sometimes with a competitive fringe. Concentration may increase with the size of the market, unlike in the standard Cournot entry model. Entry barriers and competition policy may have distinct effects depending on the demand regime, which has implications for optimal policy in rich vs. developing countries.

Keywords: Horizontal integration; incomplete contracts; theory of the firm; free entry; hold-out; merger paradox; OIO

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[†]Université libre de Bruxelles (ECARES), Northeastern University and C.E.P.R

[‡]Boston University and C.E.P.R.

[§]Université libre de Bruxelles (ECARES)

1 Introduction

The most basic question in the theory of market structure concerns the number and sizes of firms that compete to sell a homogeneous good. Economists have accrued a good understanding of the roles of production technology and demand conditions in determining these outcomes and have also explored the effects of different notions of competition. But we know little about whether anything of consequence depends on what exactly is meant by a "firm."

In industrial organization (IO), firms are pre-existing and unitary entities, and explaining market structure comes down to predicting how many of them will be active in a particular market. That, in turn, reduces to comparing the market's size to some minimum efficient scale of operations. Market power originates in exogenous features of technology – scale economies or fixed costs of entry.

In reality, of course, firms are neither pre-existing nor unitary: they are formed of more primitive and – most saliently – willful elements. To accommodate the inherently composite nature of the firm, it is useful to conceive of the industry in an alternative way – the "partitional approach" – in which the elements are a population of small producers collectively capable of serving the market. The market structure question then boils down to asking how these producers would *organize* themselves into a collection of "firms," each comprising some subset of the population. Many of the basic issues are the same – how many firms, and how large is each, how does all this depend on technology and demand. One can even ask how the producers came to enter the market, and what impact that process has on market structure.

Under certain assumptions about contracting possibilities, it wouldn't matter which way we picture the market structure problem. Indeed, the partitional approach has often been consulted to provide foundations for more traditional models. But as this paper will show, in the presence of contracting frictions, and the notions of firmhood that emanate from them, thinking along partitional lines can make a significant difference. First, those frictions may be sufficient for market power to emerge, even *without* fixed costs or economies of scale. And second, predictions about how fundamentals affect market structure may in some cases differ substantially from those of the traditional approach.

We consider an industry populated by a large number of capacity-constrained producers, called "teams," comprising an asset and two managers. The team is the minimum efficient scale of operations and contributes a tiny share to the market. Because of non-contractibility of certain inputs or production decisions such as effort, the teams suffer incentive problems. There are no fixed costs of production, and therefore no technologically mandated reason for market power to emerge. Yet producers can in principle band together, and would benefit from doing so, if that provided a commitment to exercise market power.

The property-rights theory of the firm provides a simple and natural mechanism by which these horizontally integrated firms can form and cohere, namely through the sale of the producers' assets to professional managers (HQs), who subsequently maximize profit in Cournot competition with other HQs. Since an HQ now owns and controls the assets he has purchased, she is able to prevent any one of her subordinate producers from cheating on restricted supply.

In order to focus on the distinctive effects of contracting frictions, we avoid technological assumptions that would gravitate toward any particular market structure. There are no technologically determined fixed production costs or scale economies to generate market power: team outputs aggregate linearly within and across firms. At the other end of the scale, there is no inherent limitation to the size of a firm: an HQ may operate as many teams as she likes without loss. Nor does managerial resource scarcity play any role, as HQs are abundant.

Naturally, there are important distinctions between a firm in our model and the standard one in IO. Among these is that the HQ has no more power to commit to particular output levels than do members of a team, for she has access to the same sets of contracts that they do. While team members' incentives would be driven by tradeoffs between private effort costs and (shares of) profits, HQs are only motivated by profit, and so don't take team members' private costs into account. The result is that no ownership structure – the stand-alone team or an integrated one that is owned by an HQ either by itself or with other teams – can deliver first-best surplus. The surplus gap among all these imperfect instruments ultimately is what allows oligopoly to emerge.

There are also differences between our firms and those in the standard theory of the firm, which arise from our consideration of the production of perfect substitutes. In the most common organizational economic (OE) parable, producers of complementary goods (as auto bodies and automobiles) are deciding whether to operate within or across the firm boundaries. Either way, the two parties must deal with each other in order for the product to have any social value. In other words, their assets are complements. In our setting this is not true: there is no social value to having the assets work in concert, for they are perfect substitutes. Only the prospect of raising the price creates a common interest for the parties.

This distinction raises the question whether the forces governing the determination of horizontal firm boundaries integration differ in any significant way from those governing vertical and lateral integration. As it turns out, some of them do: there is a force that limits firm size in our model that is quite distinct from those in the standard theory, and has nothing to do with the various internal diseconomies of scale that are usually invoked.

That force is the "hold-out problem." For producers, the market price acts like a public good, since it jointly benefits all the producers in the market. Like all public goods, the provision of high prices through market power is subject to a free rider problem. Normally in IO this point is recognized through ex-post behavior, as members of a cartel or syndicate are tempted to cheat on tacit agreements by overproducing. We have already mentioned that property rights provide a simple solution to that problem.

But that does not make potential free riding vanish: it is instead displaced to an ex-ante stage when the firm forms. Selling one's assets is voluntary, and one is naturally going to seek the best deal, which had better compensate at least for what one could garner when not joining the firm. Since the market price can be enjoyed whether or not one is a member of a large firm, exclusionary dealing arrangements apart, the value of producing as a stand-alone unit serves as a lower bound on what any member of a firm should extract from the relationship.

Indeed, the hold-out problem provides a powerful discipline on market power. As demand increases, the price that a monopoly could support also increases. But this makes sitting outside the monopoly as a stand-alone firm more attractive. At some point, no one would want to join the monopoly. But a duopoly, which would sustain a lower price, might be viable, until demand increases further. And so on.

What prevents stand-alone producers from undermining any sort of oligopoly? Here a second element of our model, contracting imperfections, plays a crucial role. These non-contractibilities make it impossible for producers to commit to particular output levels at the time of firm formation. Instead there is a limited menu of imperfect solutions: suffer a moral-hazard-in-teams problem and produce too little; engage an HQ as a stand-alone perfect competitor, who will then "overwork" his subordinates and impose high private costs on them; or join a firm. In a large firm, the HQ would take account of his market power, holding back production – and crucially, though not intentionally – imposing lower costs on the producers. This "quiet life" effect – which would not arise when output is contractible – allows larger firms to survive in equilibrium. We show that smaller firms work their teams harder, both within and across market structures: life is quieter in larger firms and where market concentration is higher.

Thus, in our model, *contracting imperfections are the source of market power.* Indeed, if output were contractible, and there was an oligopoly sustaining some high price, a stand-alone producer could replicate the benefit of being in the oligopoly by writing a contract to produce at the same (per capita) level as the oligopoly does, without affecting the market price. But then it could do strictly better by contracting on some other output level. Thus, coupled with contractibility, the hold-out problem ensures perfect competition is the only equilibrium outcome.

The potential for free riding not only limits concentration, it also limits competition. If the oligopoly has too many small firms, prices will be low and workloads intense – making it more attractive to remain outside as a low-productivity team or even not to produce at all.

Free-riding is at the heart of some novel comparative-static properties of the market structures predicted by our model. For example, in contrast to the standard IO prediction of the effects of *market size* on industry concentration – it decreases with market size – our model predicts the opposite: *growing markets are a force for increasing market power.*

The reason is that the relative attractiveness of joining a firm and remaining outside change with market power. Oligopolistic firms can take advantage of larger markets by expanding output, even if the net effect on price is small. But stand-alone perfect competitors will benefit little, especially when price doesn't change much. This makes outsiders more willing to join firms, increasing their size, and sometimes reducing their number.

So far, we have identified two economic forces – free riding and non-contractibility – that together, along with market demand, place upper and lower limits on the degree of competition. In general this restriction is compatible with several possible market structures. The next step is to identify an equilibrium outcome. Here we take a cooperative approach, seeking allocations that are "stable" in the sense that they satisfy three conditions. First, equilibrium must satisfy a no-free riding property – no team can do strictly better standing alone than joining a firm. Second, identical teams must have identical payoffs – the so-called equal treatment property – because any worse-treated team could simply underbid a better-treated one, making itself and the better-treated team's partners better off. We call any allocation satisfying these two conditions *admissible*. Finally, no coalition of teams can improve on their current situation by accepting an offer from an HQ that is credible in the sense that everyone in the coalition can see their way, through a finite sequence of offers from (possibly other) HQs, to a situation that is both admissible and makes the first coalition (and, by equal treatment, every team) better off.[1] Offers that don't satisfy this criterion are deemed not credible simply because they would be undermined by reactive offers from other HQs or (positive measures of) teams.

Equilibrium market structures specify the number of oligopolistic firms, together with the size of a competitive "fringe" of stand-alone producers. Given an abundant supply of HQs to run the firms and make offers to form them, we show that every equilibrium consists of points in the admissible set that maximize the per-team surplus; except for a zero measure of demand parameters, this identifies a unique market structure. The equilibrium degree of oligopoly, and the size of the competitive fringe, will be the smallest that do not violate no-free-riding constraints.

Among the main characterization results of equilibrium outcomes:

- When the demand is not too low, market structure will consist of an oligopoly that may be accompanied by a competitive fringe. When demand is very low however, only perfect competition among low-productivity teams emerges.

- All oligopolies are symmetric, a result not only of the fact that teams are ex ante identical, but also of the quiet-life effect. Two firms with different sizes (measure of teams) produce the same output under Cournot competition, so the teams in the smaller firm must be working harder. The same output could be produced by two equal sized firms, but the the average of the teams' (convex) costs would be lower.

- In a "high demand" region of parameter space, the degree of oligopoly (which, because of the possible presence of the competitive fringe, is not quite inversely related to the level of concentration, at least as measured by a Herfindahl index) will be decreasing in the elasticity of demand. Since in general there will be several higher degrees of oligopoly that still generate positive surplus for producers, there is scope for competition policy to increase consumer welfare by limiting the size of firms.

- The Herfindahl index and the equilibrium price follow a fluctuating patterns as a parameter representing demand elasticity changes, and concentration can increase locally when elasticity decreases.

[1] Our equilibrium concept leads to outcomes that are in the *far sighted stable set* (Ray and Vohra, 2015).

- As we have mentioned, market size effects differ markedly from those in the standard IO entry model. There, increasing market size increases competition. On the contrary, in an organizational market structure model, increasing the market size is a force for *increasing* concentration.

- In the low demand region, the character of the equilibrium is quite different. At very low levels of demand, the outcome is perfectly competitive, but each producer operates in a low-productivity, non-integrated, form. This is similar to results in our earlier treatment of perfectly competitive markets (Legros and Newman, 2013), in which low prices lead to non-integration. But as the demand increases slightly, a monopoly forms. And this monopoly operates more, rather than less, efficiently than the competitors would. Thus, in this low range of demand, breaking up the monopoly would be counterproductive for producers and consumers alike. By the same token, encouraging monopoly instead of competition at this very low end would actually benefit consumers. This situation is evocative of British competition policy in the age of deflation in the 1930s (Crafts, 2012), and the result has something to say about how policy makers should be approaching competition policy in emerging-market economies.

All of these outcomes occur, as we have said, without any fixed costs, where the existing set of producers could, but for the contracting problems, serve the entire market without any efficiency losses at all. The lesson for empirical understanding of trends in market structure (e.g., increasing concentration) are that changes in technology need not be the source. Increases in concentration could stem from increasing market size, a result of globalization or economic or population growth. It could also stem from decreasing contractibility – as seems plausible in the case of highly uncertain or innovative technologies especially in the knowledge economy, or as world events undermine, or at least transform, institutions that enforce traditional property rights or change the terms of corporate governance.

So much for what IO can learn from OE. What about the reverse? As we noted, with complementarity of assets or activities as the traditional building block of organizational economics, the limits to firm size stem from some sort of internal diseconomies. Examples include "Coasian" costs such as bureaucratic rigidity or hierarchical control losses. Or in the Arrovian tradition, large organizations may also be too diverse to be efficiently or cohesively governed. Either way, the costs of firm formation are increasing in the size of the firm. Less essentially, but just as commonly, internal diseconomies are typically independent of the environment in which the firm in question is sitting.

Our model differs from these two distinct ways. Foremost, the principle cost of joining a firm is the private, "Hicksian" one – how hard the producers will have to work. And here the effect is essentially opposite to the Arrow/Coase one: costs are decreasing in firm size, all else equal, precisely because life will be quieter in a firm with more market power. What is more, the cost depends on the firm's environment. The number of competing firms matters, given firm size, as does demand – more of either increases costs.

This is no mere window dressing. If the Hicks effect were not present, and instead private or other firm formation costs were globally increasing in firm size, then just as with complete contracting, the only outcome would be perfect competition. For in that case, any producer could do strictly better by staying outside of a firm, enjoying the price set by a putative oligopoly while benefiting from lower costs. Firm size is limited by the external (and endogenous) free riding problem, not by any internal diseconomies. The intuitions about the limits to firm size, so well-honed from thinking about firms in isolation, need revision when one starts to think about them interacting with each other.

Literature

Our partitional approach to market structure is inspired by the literature on coalition production economies (e.g., Hildenbrand, 1968; Boehm, 1973; Ichiishi, 1977), where the chief interest was in foundations for competitive analysis. Closer to the issues discussed here is a literature on syndicates (Aumann, 1973; Guesnerie, 1977; Legros, 1987) which analyzes when a coalition of producers benefits from forming a monopoly, as well as the literature on coalition formation with or without externalities (see Ray and Vohra, 2015 for a survey). More recently, though not aimed at the market structure question, virtually all of the formal literature on firm boundaries (particularly those descending from Grossman and Hart, 1986 and especially Hart and Moore, 1990) adopt some form of this approach.

Our approach to integration is borrowed from the property rights theory of firm (Grossman and Hart, 1986). Integration changes the nature of the incentive problem. Non-integrated teams tend to under-value coordination and over-value private cost savings. If the team relinquishes control to a third party, an HQ who behaves competitively will favor coordination and high effort from the team members (as in Legros and Newman, 2013). The novelty in this paper is to allow an HQ to integrate many teams and achieve market power, and, contrary to Legros and Newman (2013), provide a quiet-life to the team members. As will become apparent, this quiet-life is an essential subsidy for joining the oligopoly; without it the incentives to hold out would be too strong for anything but perfect competition to be sustained.

There has been an active research on the role of competition on the provision of incentives in principal-agent models (starting with Hart, 1983, see also Martin, 1993; Raith, 2003; Legros and Newman, 2014 provide a survey of this literature.) There, the boundaries of firms as well as their market behavior (e.g., Cournot or competition) is unchanged when the market structure (in particular, number of firms or demand) conditions change. By contrast, firm boundaries and market behavior are jointly determined with the market structure in the present paper.

In oligopoly theory, firms are assumed to have market power, and market structures are obtained by assuming a fixed cost of entry. The higher the fixed cost,; the higher the concentration in the industry. An exception is (Sutton, 1991) theory of endogenous market structure in which firms invest and create an industry wide externality: when the number of firms increase, incentives to invest decrease and this reduces the benefit of entry. For some demand functions, there exist equilibria in which a finite number of firms enter, even if the fixed cost is close to zero.

In general, whether there is a fixed cost of entry or an industry wide externality that limits the benefits of entry, higher demand – specifically in the form of greater market size – will lead to more entry and lower concentration in the industry. The contrast with our result is striking. In our model, when size increases, the hold-out constraint is relaxed: the payoff from being in the fringe is largely independent of size, while oligopoly payoff rise quickly with size, giving it a comparative advantage and allowing for increased concentration.

A growing empirical literature is documenting decades-long trends of increased market concentration across a wide variety of countries, industries, and regulatory regimes (e.g., De Loecker and Eeckhout, 2017, 2018; Autor et al., forthcoming). While it is possible that these patterns are being generated by technological changes that increase entry costs or efficient scales in all of these contexts, our model suggests that an alternative driving force could be the increase in market size that comes with growth or globalization. At a more micro level, it could account for rising concentration of healthcare markets following implementation of the Affordable Care Act (Nicholas C. Petris Center, 2018).

2 A Model of Endogenous Market Structures

We consider an industry with a unit measure teams comprising an asset and two risk neutral managers U and D. For example the asset could be a restaurant, the managers a chef and a maître d'hotel. Or a medical practice, with the doctors as the managers, and the office, instruments, even the group's reputation as the asset. Each manager is associated with a production decision, $d \in [0,1]$ for D and $u \in [0,1]$ for U that impose private costs d^2 on D and u^2 on U. These costs unaffected by who actually makes the decision.

Decisions (u,d) yield a probability of success of the team of $x(u,d) = \min(1, u+d)$. If the team succeeds, a unit of output is produced; otherwise it fails, and no output is produced. Hence $x(u,d)$ is also the expected output level of a team when decisions (u,d) are taken.

The demand for the product is described by the indirect demand $p = P(Q)$, decreasing in aggregate supply Q.

We are interested in two aspects of market structure.

- First is the way teams are organized. Under non-integration (NI), U will choose u while D will choose d in order to maximize their individual utility. Under integration (I), an HQ has ownership of the team and makes the decisions (u,d) to maximize here residual revenue, internalizing the private costs of U, D only in a lexicographic way.

- Second is the possibility of horizontal integration (HI). Here, an HQ can own multiple teams. If the HQ owns a positive measure of teams, the decisions made in the firm will have an effect on the aggregate output, hence the price.

We first describe what will happen in an industry with a market structure consisting of n firms of size μ_i each, hence a total oligopoly size of $\mu = \sum_{i=1}^{n} \mu_i$ and a measure $1 - \mu$ of teams in the fringe.

Fringe firms. Teams which do not belong to an HI firm behave competitively: the decisions made within the team have no effect on aggregate output, hence on the price p. The behavior of these *fringe* firms can be described simply when they are vertically integrated. Indeed, consider a VI fringe firm. The HQ has residual revenue proportional to $px(u,d))$, which is maximum for $u = d$. Since the total private cost is equal to $u^2 + d^2$, HQ will (lexicographically) choose $u = d = 1/2$, hence VI fringe teams produce one unit and generate a total surplus of

$$v_f^V(p) := p - \frac{1}{2}.$$

Hence a measure μ of vertically integrated firms produce μ.

For a NI fringe firm, it is optimal for UD to agree on an equal share of output and make lump sum transfers in order to maximize their total surplus. In the resulting decision game, where $i = U, D$ maximizes $\frac{p}{2}x(u,d) - i^2$, the equilibrium is $u = d = \min\{1/2, \frac{p}{4}\}$, implying an expected output of $\frac{p}{2}$ and a total surplus of $\frac{3p^2}{8}$ if $p \leq 2$ and of $p - 1/2$ if $p > 2$.

$$v_f^N(p) = \begin{cases} \frac{3p^2}{8} & \text{if } p \leq 2 \\ p - \frac{1}{2} & \text{if } p \geq 2. \end{cases}$$

Note that $v_f^N(p)$ is greater than $v_f^V(p)$ when $p \leq \frac{2}{3}$, which is less than 2. When the market price is p, teams have therefore a surplus in the fringe equal to

$$v_f(p) := \begin{cases} \frac{3p^2}{8} & \text{if } p \leq \frac{2}{3} \\ p - \frac{1}{2} & \text{if } p \geq \frac{2}{3}. \end{cases}$$

Oligopolistic firms. An oligopolistic firm is defined as a firm that horizontally integrates a measure μ_i of teams and that produces *stricty less* than μ_i. (By this definition, a firm that integrates all the fringe and produces at capacity is not oligopolistic.) Suppose that the fringe has size $1 - \mu$, that a proportion γ choose VI, and that there are n firms, each with size μ_i; as before $\mu = \sum_{i=1}^n \mu_i$ denotes the total size of the oligopoly.

Firms in the fringe take the price as given and anticipate the price to be equal to p^*. Then the HQ of firm i maximizes its profit function $q_i P(Q)$, where $Q := \sum_{j=1}^n q_j + (1-\mu)(\gamma + (1-\gamma)p^*/2$. From the behavior of the fringe, $\gamma = 1$ if $p^* > 2/3$ and $\gamma = 0$ if $p^* < 2/3$. The Cournot equilibrium yields the same output $q(n, \mu|p^*)$ for each firm and, for consistency, it must be the case that

$$P(nq(n, \mu|p^*) + (1-\mu)(\gamma + (1-\gamma)p^*/2) = p^*.$$

At the risk of abusing notation, we denote by $q(n, \mu)$ the equilibrium Cournot quantity, and $p(n, \mu)$ the equilibrium price when the consistency condition is satisfied. Note that these values depend only on the aggregate oligopoly size, not on the relatives sizes of firms.

In equilibrium firm i produces at less than capacity when $q(n,\mu)$ is inferior to μ_i (since each team can produce one unit at most). If this is not the case, then firm i best response is to produce μ_i, but then its behavior is observationally equivalent to a situation with $n-1$ firms and the μ_i teams in the fringe choose VI. We call firms that produce less than their full capacity *oligopolistic* because they use their size to exert market power. This motivates the following definition.

Definition 1. A market structure is a number n of firms, each with a measure $\mu_i,\ i=1,\cdots,n$ of teams together with a measure $1-\sum_{i=1}^n$ of fringe firms and their organization (nVI or VI) such that the Cournot equilibrium played by the n firms is such that $q(n,\mu)<\mu_i$ for all $i=1,\ldots,n]$.

Hence an oligopoly market structure specifies the oligopoly $(n,\{\mu_i\},i=1,\ldots,n)$ together with the way fringe firms are organized. For simplicity, we call oligopolistic firms "firms."

Private costs. The HQ of firm i will target a production level of $q(n,\mu)$, the Cournot equilibrium quantity. Hence each team j should have an expected output of x_j in such a way that in aggregate the output is $q(n,\mu)$. In order for the teams j to produce x_j, decisions must be such that $\int_{j\in i}|d_j-u_j|dj=1-q(n,\mu)$, implying a private cost of $\int_{j\in i}(u_j^2+(1-d_j)^2)dj$. Since HQ wants (lexicographically) to minimize the private costs of the teams, it is optimal for each (almost all) team to have an expected output of $\frac{q(n,\mu)}{\mu_i}$ and to impose decisions $d=1-u=\frac{q(n,\mu)}{2\mu_i}$. It follows that the private cost of a team in firm i is

$$c(\mu_i|n,\mu):=\frac{1}{2}\frac{q(n,\mu)^2}{\mu_i^2}. \tag{1}$$

This illustrates the "quiet life" that teams enjoy in larger firms: as μ_i increases, their private cost decreases.

We now highlight two restrictions that admissible market structures must satisfy in order to be realized. First, teams must be willing to fill in the offers, that is each firm i can attract the μ_i measure of teams in its offer. This condition is fulfilled as long as the market structure yields outcomes that satisfy a no free riding condition, that is no team preferring being in the fringe than in a firm. Second, the asset prices must be renegotiation proof, in the sense that there is no HQ and team that are willing to re-contract.

Participation constraint, No Free Riding condition. Since a team can insure a surplus of v_f by not joining a firm, a necessary condition for feasibility of the market structure is that the surplus of a team is at least equal to

$$v_f(p) = \begin{cases} \frac{3}{8}p^2 & \text{if } p \leq \frac{2}{3} \\ p - \frac{1}{2} & \text{if } p \geq \frac{2}{3}. \end{cases} \tag{2}$$

where p is the putative market price. High prices, the usual consequence of market concentration, are now subject to a free riding conditions: too high a price and teams will prefer to free ride on the price and be part of the fringe. This puts an upper bound on the degree of concentration in the market. Too low a price will make NVI the desired choice in the fringe, and teams may prefer this than being forced to coordinate in a firm. This would put a lower bound on the degree of concentration in the market.

Firms are formed by transferring ownership to an HQ. A market structure $(n, \{\mu_i\})$ is the consequence of HQs making offers (r_i, μ_i), where r_i is the asset price that the HQ wants to pay for each of μ_i teams. (As noted before HQs who are supposed to control VI fringe teams have to offer an asset price $r_f = p$, where p is the anticipated market price.) Given these offers, the surplus of a team joining firm i is

$$v(r_i, \mu_i | n, \mu) = r_i - c(\mu_i | n, \mu),$$

where $c(\mu_i | n, \mu)$ is the private cost in (1).

Asset prices are not renegotiated. Consider an acceptable set of offers $(r_i, \mu_i), i = 1, \ldots, n$ and a resulting market structure $(n, \{\mu_i\})$. Conditional on having these offers, it is not possible for a team and a HQ to contract on the asset price r_i and both be better off. Suppose that offers lead to unequal treatment among teams, that is, there exists $i \neq j$ such that $v_i > v_j$. Since all teams in j would prefer to be in firm i, it is possible for the HQ of firm i to offer a lower asset price, say $r_i - (v_i - v_j)$ while still attracting teams, a contradiction. Hence, it must be the case that $v_i = v_j$ for all i, j. Similarly, if there are teams active in the fringe (when $\mu < 1$), equal treatment requires that $v_i = v_f$ for all i.

Definition 2. Offers $o = [(r_i, \mu_i), i = 1, \ldots, n]$ are *acceptable* if each HQ makes a non-negative profit, and if there exists $v(n, \mu) \geq v_f(p(n, \mu))$ such that teams in the oligopoly are treated equally, that is for each i, $v(r_i, \mu_i | n, \mu) = v(n, \mu)$, and $v(n, \mu) = v_f(p(n, \mu))$ when $\mu < 1$.

3 Equilibrium Market Structures.

Acceptable offers are consistent with positive profits by HQs (that is with $p(n,\mu)q(n,\mu) > \mu_i r_i$). If this is the case, one expects HQs to enter at the offer stage and compete away these positive profits. Equilibrium structures should be stable to alternative offers made by HQs.

An acceptable offer $o = [(r_i, \mu_i), i = 1, \ldots, n]$ induces a market structure (n, μ). Consider another acceptable offer $o' = [(r'_j, \mu'_j), j = 1, \ldots, m]$ that generates the market structure (n', μ'). We say that o' dominates o if all teams are better off in the market structure (n', μ').

Our stability concept is the following.

Definition 3. Acceptable offers $o = [(r_i, \mu_i), i = 1, \ldots, n]$ are *stable* if there does not exist a competing set of acceptable offers $o' = [(r'_j, \mu'_j), j = 1, \ldots, n']$ that dominates o.

With some abuse, we will say that acceptable offers generate acceptable structures (n, μ).

For instance, suppose that the initial offers $o = [(r_1, \mu_1), (r_2, \mu_2)]$ generate a duopoly, but that HQ of firm 1 makes a positive profit $\pi_2 = p(2,\mu)q(2,\mu) - \mu_1 r_1$. If an HQ makes offer (r_3, μ_1), where $r_3 \in (r_1, p(2,\mu)q(2,\mu)/\mu_1)$, the offers $o' = [(r_3, \mu_1), (r_2, \mu_2))]$ are acceptable and induce the same market structure (hence same price and quantity) as o, but teams in firm 3 are better off than in firm 1. Alternatively, and HQ could enter and offer $o' = [(r_3, \mu_1 + \mu_2)]$, effectively hoping to create a monopoly. If such an offer is acceptable, then the duopoly structure is not stable in our definition.

What is immediate from our definition is that stable structures should yield zero profits for the HQs. Indeed, if $o = [(r_i, \mu_i), i = 1, \ldots, n]$ does not satisfy zero profit π_i, there exists another offer $o' = [(r'_i, \mu_i), i = 1, \ldots, n]$ with $A'_i > r_i$ whenever $\pi_i > 0$ that is acceptable and yields positive profits for the HQs who make the competiting offers.

Since acceptable offers yield an equal treatment property among teams in firms, another consequence of stability is the symmetric structure of oligopolies. Indeed, in an admissible structure $(n, \{\mu_i\})$, the surplus of teams in firm i is equal to

$$v_i = p(n,\mu)x_i - \frac{1}{2}x_i^2$$

where $x_i := \frac{q(n,\mu)}{\mu_i}$. By equal treatment, for any two firms i, j, we must have $v_i = v_j$, and because the surplus is concave in x_i, there can be at most two sizes, $\mu_0 < \mu_1$ of powerful firms consistent with equal treatment. Suppose that there are n_0, $0 < n_0 < n$, firms of size μ_0 and $n_1 = n - n_0$ firms of size μ_1. By construction, $n_0\mu_0 + (n - n_0)\mu_1 = \mu$ and furthermore $\frac{q(n,\mu)}{\mu_0} < 1$ (otherwise some firms are not powerful).

Consider a new structure with the same number of firms of equal size $(n, \{\mu/n\})$. By construction, the equilibrium price and per-firm quantity are the same as before and furthermore each firm is powerful because $\frac{nq(n,\mu)}{\mu} < 1$. Now, because $\frac{q(n,\mu)}{\mu_1} < \frac{q(n,\mu)}{\mu/n} < \frac{q(n,\mu)}{\mu_0}$, concavity of the surplus function implies that the surplus of each team is strictly greater in the structure $(n, \{\mu/n\})$ than in the structure $(n, \{\mu_i\})$. Therefore stable structures must be symmetric.

Lemma 1. *Stable offers induce a symmetric oligopoly in which the per-team surplus in olipolistic firms*

$$v(n,\mu) = \frac{np(n,\mu)q(n,\mu)}{\mu} - \frac{q(n,\mu)^2}{2}\frac{n^2}{\mu^2}.$$

Stability also implies (constrained) efficiency. Indeed, suppose that a set of offers yields a market structure (n, μ). Then in equilibrium each team in the oligopoly obtains $v(n, \mu)$. If there exists another structure (n', μ') for which $v(n', \mu') > v(n, \mu)$ then there exists a set of offers that is acceptable and dominates o, which is a contradiction.

Proposition 1. *Stable offers induce market structures that solve*

$$\max_{(n,\mu)} \; v(n,\mu) \qquad \text{(P)}$$
$$s.t \; v(n,\mu) \geq v_f(p(n,\mu)).$$

As we show in the Appendix A.2, our stable outcome coincides with the farsighted stable set in Ray and Vohra (2015), which is a singleton in our case.

3.1 A Characterization

We restrict attention to inverse demand functions that are log-concave (a leading case are linear demand functions $P = \alpha - \beta Q$). This is a sufficient condition for having a quasi-concave problem for Cournot firms and it implies that the ratio $-\frac{P(Q)}{P'(Q)}$ is a decreasing function of Q.

Assumption 1. *The inverse demand function* $P(Q)$ *is log-concave, that is the ratio* $\rho(Q) := -\frac{P(Q)}{P'(Q)}$ *is a decreasing function of* Q.

For completeness, we state a direct consequence of Assumption 1 (all proofs missing from the text are in the Appendix.)

Claim 1. *Under Assumption 1, the Cournot quantity* $q(n)$ *in a full-oligopoly is a decreasing function of* n*, and the total quantity* $nq(n)$ *is an increasing function of* n.

A structure is admissible if the surplus of a team in an oligopoly is greater than $v_f(p(n,\mu))$. Because $v_f(p(n,\mu))$ is greater than $\frac{3}{8}p(n,\mu)^2$, the surplus is necessarily positive. We use the convention that n denotes a real number and N denotes an integer; hence market structures are of the form (N,μ).

Lemma 2. *There exist functions* $\underline{n}(\mu)$ *and* $\overline{n}(\mu)$ *such that, a structure* $(N,1)$ *is admissible if, and only if* $N \in [\underline{n}(1), \overline{n}(1)]$. *A structure* (N,μ) *with* $\mu \in (0,1)$ *is admissible if, and only if,* $N = \underline{n}(\mu)$.

Proof. The fringe firm has value $p(n,\mu) - \frac{1}{2}$ if $p(n,\mu) \geq \frac{2}{3}$, which imposes an upper bound on n: $n \leq n_1(\mu)$. The admissibility condition $v \geq v_f$ is $\frac{1}{2}\left(1 - \frac{(nq(n))^2}{\mu^2}\right) \geq p(n,\mu)\left(1 - \frac{nq(n)}{\mu}\right)$, or, $\frac{1}{2}\left(1 + \frac{nq(n)}{\mu}\right) \geq p(n,\mu)$. By Claim 1, there exists a unique $n_0(\mu)$ for which the admissibility condition holds if, and only if, $n \geq n_0(\mu)$.

If $p(n,\mu) \leq \frac{2}{3}$, that is if $n \geq n_1(\mu)$, the admissibility condition reduces to $p(n,\mu)\left(\frac{nq(n)}{\mu} - \frac{3}{8}p(n(\mu)\right) \geq \frac{1}{2}\frac{(nq(n))^2}{\mu^2}$, and a necessary condition is that $\frac{nq(n)}{\mu} > \frac{3}{8}p(n,\mu)$, hence that n is bounded above by a bound $n_2(\mu) > n_1(\mu)$.

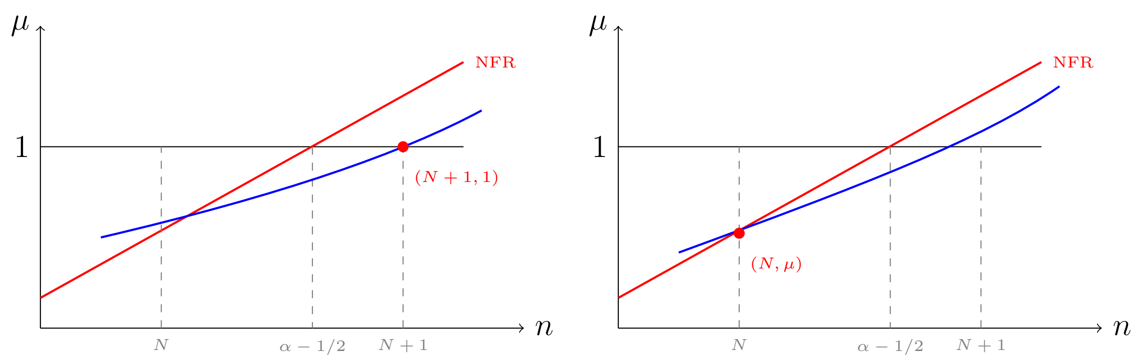
Therefore, admissible structures consistent with $p \leq 2/3$ must be such that $n_1(\mu) \leq N \leq n_2(\mu)$ and admissible structures consistent with $p \geq 2/3$ must be such that $n_0(\mu) \leq N \leq n_1(\mu)$, proving the lemma. □

Turning now to stability, we can show that the surplus in an oligopoly team is a decreasing function of n and an increasing function of μ. The previous lemma then implies a simple characterization of the stable structure.

Indeed, consider a minimally admissible full-oligopoly $(N,1)$ with $N \geq 2$. Then, structures $(N',1)$, $N' < N$ are not acceptable. Because $v(n,1)$ is a decreasing function of n, the surplus under $(N',1)$ is strictly larger than the surplus under $(N,1)$. Going from a N' full oligopoly to a $N > N'$ full oligopoly generates a first order loss for teams. By contrast, going from a N' full-oligopoly to a (N',μ) partial-oligopoly generates a second order loss when μ is small. Therefore if $v(N',\mu) \geq v(N,1)$, the stable structure is a partial oligopoly.

Proposition 2. *Consider a minimally admissible full oligopoly* $(N, 1)$*. If* $N = 1$*, the stable structure is* $(1, 1)$*. If* $N \geq 2$*, for each* $N' < N$ *let* $\mu(N')$ *solve* $v(N', \mu(N')) = v_f(N', \mu(N'))$*. The optimal structure is* $(N, 1)$ *if for each* $N' < N$*,* $v(N', \mu(N')) \leq v(N, 1)$*, otherwise the stable structure is a partial oligopoly.*

Our assumption of log-concavity insures that stable market structures are generically unique when demand is large enough. Indeed, assuming that the equilibrium price is greater than $P_0 = 2/3$, in the (n, μ) space, the graph of the iso-surplus curve $v(n, \mu) = v$ intersects the graph of the constraint $v(n, \mu) = p(n, \mu) - \frac{1}{2}$ from above. It follows that if $(N + 1, 1)$ is the minimally admissible full oligopoly, we can have one of two situations, as represented by the two panels of figure 1. In the left panel, the minimally admissible full oligopoly $(N + 1, 1)$ is stable because the best admissible partial oligopoly (N, μ) yields a lower team surplus. In the right panel, the opposite is true and the stable structure is the partial oligopoly. These two situations are generic, but it is possible that both (N, μ) and $(N + 1, 1)$ yield the same surplus in which case there can be two stable structures.



(a) Full Oligopoly

(b) Partial Oligopoly

Figure 1: Stable Structures

Corollary 1. *Assuming that the equilibrium price is greater than* $2/3$*, there exists generically a unique stable structure.*

4 Increasing Market Size

4.1 Demand Shifters

Suppose that there is an increase in the market size σ, that is the demand function is $Q = \sigma D(p)$. Then the inverse demand is now $p = P(Q/\sigma)$. In classical Cournot models where long run equilibria are driven by fixed costs, an increase in market size leads to more entry, hence less concentration in the industry. We will see that with organizational firms, larger markets weaken the NFR constraint and are therefore drivers of more concentration in the industry.

Consider the equilibrium structure (N, μ) of Proposition 1 when $\sigma = 1$ and consider a small increase in S. Let $q(N, \mu; \sigma)$ be the Cournot equilibrium quantity in a firm when the fringe contains $1 - \mu$ teams and the market size is equal to σ; absent the reference to σ, functions are evaluated at $\sigma = 1$. Suppose first a full-oligopoly, that is $\mu = 1$. A first observation is that the quantity of a firm solving the FOC for a firm is homogeneous of degree 1 is σ, that is if $q(N, 1; \sigma)$ is the Cournot quantity when there are n firms in a full oligopoly and the market size is σ.[2]

Lemma 3. *If the oligopoly integrates all teams at $\sigma = 1$, then for local change in σ, the per firm quantity $q(N; \sigma)$ in that oligopoly is homogenous of degree one, that is $q(N, 1; \sigma) = \sigma q(N, 1; 1)$.*

Homogeneity of degree one of the Cournot quantity $q(n; \sigma)$ implies that the equilibrium price, hence the surplus of teams in the fringe, is unchanged when S increases. If the surplus of teams in oligopolistic firms increases with S, the NFR condition becomes less binding as S increases. To show this, note that the per-team surplus in the oligopoly is

$$v(n, 1; \sigma) := P\left(\frac{nq(n, 1; \sigma)}{\sigma}\right) nq(n, 1; \sigma) - \frac{(nq(n, 1; \sigma)^2)}{2} \tag{3}$$

$$= P(nq(n, 1))Snq(n, 1) - \sigma^2 \frac{(nq(n, 1))^2}{2}. \tag{4}$$

and the variation with respect to S evaluated at $S = 1$ is

$$\left.\frac{\partial v(n, 1; \sigma)}{\partial \sigma}\right|_{\sigma=1} = P(nq(n, 1; 1))nq(n, 1; 1) - (nq(n, 1; 1))^2$$

$$= v(n, 1) - \frac{(nq(n, 1; 1))^2}{2}.$$

Because $(N, 1)$ is the equilibrium structure when $\sigma = 1$, the free-riding condition is satisfied and therefore the variation is greater than $v_f(n, 1) - \frac{nq(n,1;1))^2}{2}$. Now, $v_f(n, 1) \geq p(n, 1) - \frac{1}{2}$, hence if $p(n, 1) > 1$, $v_f(n, 1) > \frac{1}{2}$, and since $nq(n, 1) <$

[2]This is immediate from the first order condition: $P(nq/\sigma) + P'(nq/\sigma)q/\sigma = 0$, implying that $q(n, 1; \sigma)/\sigma = q(n, 1; 1)$. Clearly, the argument is also valid if there is a constant marginal cost of production. Our definition of an oligopoly insures that $q(n, 1; 1)$ is an interior solution, that is that $q(n, 1; 1) < 1/n$.

1, the variation of the surplus of teams in oligopolistic firms is positive when σ increases. Hence, the free-riding constraint is less binding as σ increases. Hence, *for full oligopolies, an increase in market size is a force towards more concentration.*

Note that even if the NFR constraint is less binding, an increase in market size may not modify the market structure (indeed, while the solution to $v(n,1;\sigma) \geq v_f(n,1)$ decreases with σ, the *integer* solution may not). Hence, increased market size may lead to no observed change in concentration or in the equilibrium price. This is not the case when the equilibrium is a partial oligopoly, for then when market size increases the oligopoly will integrate more teams, hence the competitive fringe will shrink and the market price will increase.

Lemma 4. *If (N,μ) is an equilibrium with a partial-oligopoly, there exists $\sigma^*(\mu) > 1$ such that for any $\sigma \in (1, \sigma^*(\mu))$, there exists $\hat{\mu} > \mu$ such that the partial oligopoly $(N, \hat{\mu})$, $\hat{\mu} > \mu$, satisfied NFR and makes all teams better off.*

Therefore, when the shock applies to a partial oligopoly, the oligopoly integrates more teams and the equilibrium market price increases.

Proposition 3. *Small positive shocks to demand are a force towards more concentration and higher prices. If the initial equilibrium is a full oligopoly $(N,1)$, either the market structure and the price do not change or the new market structure is $(N-1,\mu)$ with a larger surplus to teams and a larger price. If the initial equilibrium structure is a partial oligopoly (N,μ), the new equilibrium is $(N,\hat{\mu})$ with $\hat{\mu} > \mu$ and a larger market price.*

To analyze the evolution of the market structure when σ increases, let us reconsider the condition for admissibility of a structure $(n,1)$. Let $Q(n)$ is the Cournot outcome with a market structure $(n,1)$ when the market size is $\sigma = 1$; the admissibility condition is then (assuming that the price is greater than 2/3)

$$\sigma P(Q(n))Q(n) - \sigma^2 \frac{Q(n)^2}{2} \geq P(Q(n)) - \frac{1}{2} \iff (\sigma - \sigma_0(n))(\sigma - \sigma_1(n)) \leq 0$$

where

$$\sigma_0(n) := \frac{1}{Q(n)}; \sigma_1(n) := \frac{2P(Q(n)) - 1}{Q(n)}.$$

Therefore, defining[3]

$$\underline{\sigma}(n) := \min(\sigma_0(n), \sigma_1(n)); \; \overline{\sigma}(n) := \max(\sigma_0(n), \sigma_1(n))$$

[3] $\sigma_0(n) < \sigma_1(n)$ if the price is greater than 1.

a structure $(n, 1)$ is admissible if, and only if,

$$\sigma \in [\underline{\sigma}(n), \overline{\sigma}(n)].$$

Example 1. *Consider inverse demand functions* $P = \alpha - \frac{Q}{\sigma}$, *where the market size* $S = \frac{1}{\sigma}$ *is fixed. The Cournot outcome is* $p(n, 1; 1) = \frac{\alpha}{n+1}$, $Q(n, 1; 1) = \frac{n\alpha\sigma}{n+1}$. *Assuming* α *is large,* $v_f(p(n, 1; \alpha)) = \frac{\alpha}{n+1} - \frac{1}{2}$, *and the variation of* $v_f(n, 1; \alpha)$ *with respect to* α *is equal to* $\frac{1}{n+1}$. *Suppose that* $(n, 1)$ *is an admissible structure if* α. *The surplus of teams within the oligopoly is equal to* $v(n, 1; \alpha) = S\frac{n}{2(n+1)^2}\alpha^2(2 - Sn)$. *Note that*

$$\begin{aligned}
\frac{\partial v(n, 1; \alpha)}{\partial \alpha} &= \sigma\frac{n}{n+1}\alpha(2 - \sigma N) \\
&= \frac{2v(n, 1; \alpha)}{\alpha} \\
&= \frac{2v_f(p(n, 1; \alpha))}{\alpha} \\
&= \frac{2}{n+1} - \frac{1}{\alpha} \\
&= 2\frac{\partial v_f(p(n, 1; \alpha)}{\partial \alpha} - \frac{1}{\alpha},
\end{aligned}$$

and a local increase in α *(a decrease in the price elasticity of direct demand) has an ambiguous effect on whether the NFR constraint will continue to be satisfied at* $(n, 1)$, *hence whether there is a force towards more or less concentration in the industry.*

Example 2. *Consider demands* $P = \alpha(1-Q)$. *(In contrast to the previous example, a decrease in* α *increases the demand elasticity in addition to increasing the market size.) The Cournot outcome for a full oligopoly* $(n, 1)$ *is independent of* α *and is* $Q(n) = \frac{n}{n+1}$, *with associated price equal to* $\frac{\alpha}{n+1}$. *The surplus of a team in an oligopoly* (n, μ) *is equal to*

$$v(n, \mu; \alpha) = \frac{n(2\alpha\mu - n)}{2(n+1)^2}.$$

It is simple to show that $(n, 1)$ *is admissible at* α *only if* $\alpha \leq \overline{a}(n)$, *where*

$$\overline{a}(n) = n + \frac{1}{2}.$$

As α *increases slightly beyond* $\overline{a}(n)$, *only* $(n+1, 1)$ *is admissible. By the same argument as in Proposition 2, the structure* $(n, \mu(n; \alpha))$ *dominates* $(n+1, 1)$, *where* $\mu(n; \alpha)$ *solve* $v(n, \mu; \alpha) = v_f(p(n, \mu; \alpha))$. *The largest solution is equal to* $\mu(n; \alpha) = \frac{2n+1}{2\alpha}$, *and is inferior to 1 for* $\alpha \geq \overline{a}(n)$.

Now, for each n, $v(n,\mu(n;\alpha);\alpha) = \frac{n}{2(n+1)}$, is independent of α when $\alpha \geq \overline{a}(n)$ while for any $n \geq 1$,

$$\begin{aligned} v(n+1,1;\overline{a}(n)) &= \frac{(n+1)^2}{2(n+2)^2} \\ &< \frac{n}{2(n+1)} \\ &< \frac{(n+1)(n+3)}{2(n+2)^2} \\ &= v(n+1,1;\overline{a}(n+1)). \end{aligned}$$

Therefore, for any $n \geq 1$ there exists $a_0(n] \in (\overline{a}(n), \overline{a}(n+1))$ such that the equilibrium structure is $(n,\mu(n;\alpha))$ if $\alpha \in [\overline{a}(n), a_0(n)]$ and is $(n+1,1)$ if $\alpha \in [a_0(n), \overline{a}(n+1)]$.[4]

For this type of demand shift, the price is non-monotonic. Indeed, at $a_0(n)$, we have $v(n,\mu(n;a_0(n));a_0(n)) = v_f(n,\mu(n;a_0(n));a_0(n)) = v(n+1,1;a_0(n))$. Because $a_0(n) < \overline{a}(n+1)$, the admissibility constraint is slack and therefore $v(n+1,1;a_0(n)) > v_f(n+1,1;a_0(n))$, implying that, generically,

$$p((n,\mu(n;a_0(n));a_0(n)) > p(n+1,1;a_0(n)),$$

and the price decreases locally around $a_0(n)$, but the price under full oligopoly at $\alpha = n+1/2$ is increasing in n, proving non-monotonicity of the price in n. Figure 2 shows how the price fluctuates as α increases.

4.2 Increase in the Measure of Producers

It should be clear that an increase in the measure of producers has the same qualitative effects as a decrease in market size. Indeed, if m is the mass of producers and, to simplify, the equilibrium structure is a full oligopoly $(n,1)$, the price is unchanged when m varies but the private cost of each team in a firm is equal to $\frac{1}{2}\frac{(nq(n))^2}{m^2}$. This is equivalent to having a market expansion $S := \frac{1}{m}$. Therefore, an increase in m has the same qualitative effects as a decrease in S in the case of a demand shift. *Hence, an increase in the number of suppliers is a force towards less concentration.*

For instance, consider a linear demand $P = \alpha - Q/\sigma$. The linear demand exemplifies the substitute roles of an increase in market size σ and an increase in m. Indeed, as will be apparent soon, the equilibrium structure is a function of the ratio m/σ.

[4] $a_0(n) = \frac{1+7n+7n^2+2n^3}{2(1+n)^2}$.

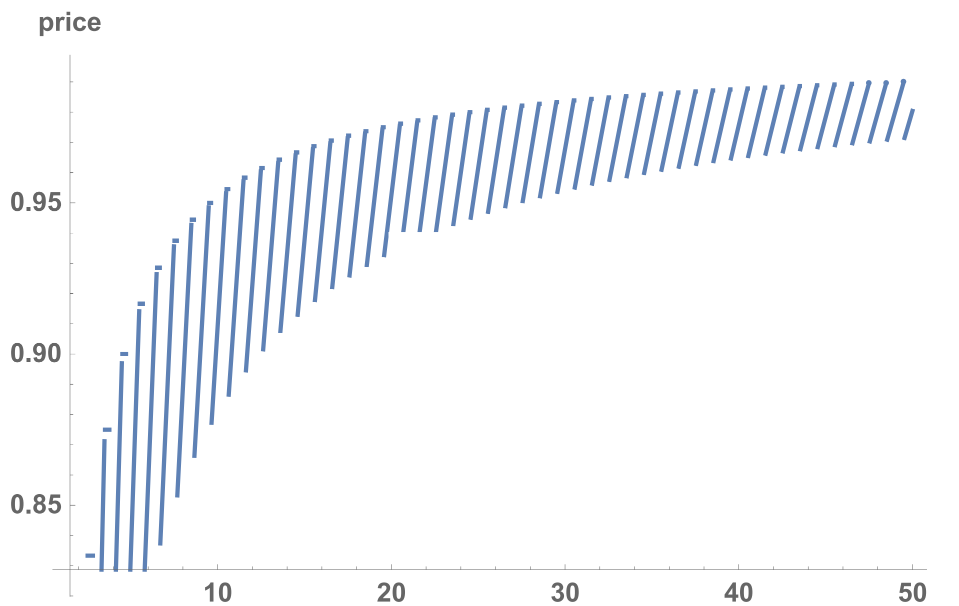


Figure 2: Equilibrium price as α increases ($P = \alpha(1-Q)$)

If the intensity at which each team operates is x, and there is a measure m of them, then an HQ that owns one of n firms now has measure m/n and chooses $q = \frac{\alpha\sigma}{n+1}$. Thus $x = \frac{\alpha\sigma n}{m(n+1)}$, and this is also the expression for aggregate output Q. The equilibrium price will be $\frac{\alpha}{n+1}$, surplus in a stand-alone VI firm is $\frac{\alpha}{n+1} - \frac{1}{2}$, in a stand-alone NVI is $\frac{3}{8}\left(\frac{\alpha}{n+1}\right)^2$, and inside an oligopoly firm $\frac{\alpha^2\sigma n}{m(n+1)^2} - \frac{1}{2}\left(\frac{\alpha\sigma n}{m(n+1)}\right)^2$.

Ignoring integer constraints, and assuming that α is large, the minimum degree of oligopoly satisfying NFR is obtained by equating the VI and oligopoly surpluses, and is equal to

$$\underline{n} := \begin{cases} \frac{m/\sigma}{\alpha - m/\sigma} & \text{if } m/\sigma \leq \alpha - 1 \\ (2\alpha - 1)\frac{m/\sigma}{\alpha + m/\sigma} & \text{if } m/\sigma \geq \alpha - 1. \end{cases} \tag{5}$$

The maximum degree sustainable equates NVI surplus to that of oligopoly and is equal to

$$\overline{n} := \frac{3m}{2\sigma}. \tag{6}$$

Clearly, both the minimum and the maximum values of n increase when m increases or σ decreases.

5 Entry, Fixed Costs, and Regulation

So far we have supposed a fixed (unit) population of producers and asked how imperfect contracting interacts with demand to determine market structure. This is an appropriate framework for many situations, for instance if one asks how the Affordable Care Act affects the degree of concentration in the healthcare industry. But it is worth asking how things look in a longer run in which producers may enter (or exit) the industry, and the role played by fixed costs for organizational firms.

Suppose there is an investment cost F to become a producer, and consider different regulatory interventions. First a laissez- faire outcome, where producers enter and oligopolies can form freely. Second, a maximally aggressive competition policy, where the regulator imposes a number of oligopolistic firms that is consistent with teams participating in an (effective) oligopoly. Third, we analyze what would be an optimal policy. We will use the linear demand specification $P = \alpha - Q/\sigma$.

5.1 Laissez-Faire and Regulation

Laissez-Faire

As we have seen, the equilibrium price is $\frac{\alpha+\beta m}{1+2m/\sigma}$, decreasing in m/σ as long as $\alpha > 1/2$. Then when the surplus from oligopoly, which is equal to the surplus in a stand alone VI, equals this cost, we have

$$\frac{\alpha + m/\sigma}{1 + 2m/\sigma} = F + \frac{1}{2}$$

If market size increases, then there will be entry of producers to restore the equilibrium condition: m/σ must remain constant. Thus in the long run, market price and the degree of oligopoly remain the same. This is already in contrast to standard IO entry models, which would tend to have n increasing, and with it, price falling.

What is more, if the entry cost increases with the number of producers, then the same increase in σ will result in a smaller increase in m and therefore an increase in ϕ and the equilibrium price. The equilibrium concentration increases. Thus under plausible conditions, the effect of market size changes is qualitatively similar to our earlier findings, even with entry of suppliers.

What this model has in common with the broad lessons of IO is that technological or regulatory improvements that reduce entry costs or exclusivity will be procompetitive. Industries that have experienced increases market size would escape increased concentration if their entry costs decreased sufficiently (either exogenously or endogenously).

Aggressive Regulation

If the competition authority forces the oligopoly to be just large enough so that teams are just willing to participate, then the price is driven to satisfy $\frac{3}{8}p^2 = \frac{3}{8}\left(\frac{\alpha}{\frac{3m}{2\sigma}+1}\right)^2 = F$. The question as to whether policy is helpful or harmful in the long run comes down to whether $\phi + 1/2 > \sqrt{\frac{8}{3}F}$; if so policy helps, otherwise it hurts consumers. It is straightforward to see that the policy is helpful only if $F \notin (1/6, 3/2)$. But if F is less than 1/6, then the equilibrium price under laissez-faire would be too low to sustain VI as the stand-alone option, and the policy would have no bite (the laissez-faire outcome would be a large supply with a small number of firms, while the policy would induce a small supply with a large number of firms; in either case the equilibrium price would be $\sqrt{\frac{8}{3}F}$). Thus aggressive regulation is beneficial only if entry costs are high, which is consistent with current practice, but also when demand is high enough to sustain the VI as the outside option, which is less often taken into account in the practice of merger policy.

Optimal Policy

This raises the natural question of whether a better policy might exist that does not involve binding the high side of the NFR. Suppose the authority does not regulate entry of producers but can set a target n^R, i.e., imposes that firms cannot have a share of the supplier market greater than $1/n^R$. The equilibrium price under a sustainable oligopoly would be $p = \alpha/(n^R+1)$, and the per-team surplus $p^2\psi(\frac{n^R}{m/\sigma})$, where $\psi(z) \equiv z - z^2/2$. The authority wants the lowest price subject to the free entry condition $p^2\psi(\frac{n^R}{m/\sigma}) = F$, and the NVI form of the NFR which reduces to $\psi(\frac{n^R}{\beta m}) \geq 3/8$. Since $\psi \leq 1/2$, the solution is to choose $n^R + 1 = \frac{\alpha}{\sqrt{2\phi}}$; the measure of suppliers m that enters solves $\psi\left(\frac{n^R}{m/\sigma}\right) = \frac{1}{2}$, that is $m = \sigma n^R$.

5.2 Regulating or Preventing Oligopolies ?

It is fair to ask why we should restrict policy to the interval $[\underline{n}, \overline{n}]$: why not impose $n > \overline{n}$, which makes any oligopoly team irrational and thereby imposes perfect competition, either of the mixed (some vertically integrated, and some non-integrated), or purely non-integrated variety? Once again the organizational nature of firms makes for some surprising answers: even without increasing returns to scale or fixed costs, perfect competition may be worse for consumers than regulated oligopoly.

Here we confine attention to demand functions $P = \alpha(1-Q)$ and ignore integer constraints. The "aggressively" regulated monopoly with $n = \overline{n}$ achieves equilibrium price $P_R = \frac{2\alpha}{3\alpha+2}$ (clearly smaller than the laissez-faire price $\frac{2\alpha}{2\alpha+1}$). The competitive price is $P_C = \min\{\frac{2\alpha}{\alpha+2}, \frac{2}{3}\}$.[5]

Note that for any α, $P_R < P_C$. The reason has to do with the imperfections in contracting. Any competitive equilibrium entails a positive measure of non-integrated teams, which are relatively unproductive. A regulated oligopolistic equilibrium has the HQ of any powerful firm coordinating its teams more than they would choose as non-integrated stand-alones, given the competitive price for that demand. This effect is strong enough to overcome the high productivity of the vertically integrated teams (if any) that would participate in a competitive equilibrium.[6]

6 Extensions

6.1 The Ambiguous Effects of Barriers to Consumer Access on Prices

When demand is low, private costs loom large with respect to the benefits of coordination or market power. Therefore, low demand conditions may lead to equilibrium structures that are competitive, without firms having market power. But teams perform poorly because they choose NVI while firms would perform better (but impose too high a cost on teams with respect to their outside option). In other words, teams have a quiet life under competition rather than under an oligopoly when demand is low. For this reason, as we have seen in the previous section, consumers may value market power, not because large firms achieve scale economies, but because their HQs, who don't internalize the quiet life, force their teams to deliver more goods.

This brings to the fore the role of consumer access in an OIO context. In the traditional unitary firm setting, limiting access for small firms (e.g., via exclusive dealing arrangements financing constraints that favor larger entities, or regulations such as licensing; Rasmusen et al., 1991; Segal and Whinston, 2000) are a force

[5] To see this, note the competitive equilibrium under pure non-integration satisfies $P = \alpha - \alpha\frac{P}{2}$ or $P = \frac{2\alpha}{\alpha+2}$. When $\alpha > 1$, this exceeds $P_0 = 2/3$, and the equilibrium will be a mixed one in which some teams are vertically integrated and some are not; the price of P_0 ensures the teams are indifferent between the two structures. A competitive equilibrium in which all teams are vertically integrated does not exist with this demand, as the supply would be 1, which implies $P = 0 < P_0$.

[6] If the regulator wants to maximize aggregate (producer+consumer), rather than just consumer welfare, then perfect competition is indeed optimal. See Proposition 3 in Legros and Newman (2013).

towards market power and are often anti-competitive.[7] This is also the case in our model when demand is high: the fact that teams in the fringe can produce and free ride on the price generated by an oligopoly creates discipline and limits the concentration in the industry, as well as the price that consumers will pay. But this is not the case when demand is low.

We model access in a stark way by assuming that that oligopolistic firms can attract consumers with probability one but that fringe firms have a probability σ less than one of attracting consumers the market.

For simplicity, we consider a linear inverse demand function $p = \alpha(1-Q)$, where $\alpha < \frac{2}{3}$.

No Barrier to consumer access ($\sigma = 1$). In this case, the market price must be inferior to $p_0 = \frac{2}{3}$, and teams in the fringe choose NVI, produce $\frac{p}{2}$ and have a surplus of $\frac{3p^2}{8}$. A first observation is that there does not exist an equilibrium with an oligopoly (n, μ). If $\mu = 1$, the surplus of a team is $v(n, 1; \alpha) = \frac{n^2}{(n+1)^2}\left(\frac{\alpha}{n} - \frac{1}{2}\right)$ and the price is $p(n, 1; \alpha) = \frac{\alpha}{n+1}$. Hence, the NPR condition holds only if $\alpha n - \frac{n^2}{2} \geq \frac{3}{8}\alpha^2$, which requires $\alpha \in \left[\frac{2n}{3}, 2n\right]$, contradicting our assumption that $\alpha < \frac{2}{3}$. There cannot be a partial-oligopoly structure either (with $\mu < 1$). If this were the case, fringe teams produce $p/2$ and each oligopoly firm produces $q = \frac{1-(1-\mu)\frac{p}{2}}{n+1}$. For consistency, the price must solve $p = \alpha\left(1 - nq - (1-\mu)\frac{p}{2}\right)$, that is

$$p(n, \mu; \alpha) = \frac{2\alpha}{2(n+1) + \alpha(1-\mu)}.$$

Therefore each firm produces

$$q(n, \mu; \alpha) = \frac{2}{2(n+1) + \alpha(1-\mu)}$$

and the surpluses of teams in firms and in the fringe are

$$v(n, \mu; \alpha) = \frac{4n^2}{(2(n+1) + \alpha(1-\mu))^2}\left(\frac{\alpha}{n} - \frac{1}{2}\right)$$
$$v_f(n, \mu; \alpha) = \frac{3\alpha^2}{2(2(n+1) + \alpha(1-\mu))^2}$$

and the NFR constraint is satisfied only if $8n^2\left(\frac{\alpha}{n} - \frac{1}{2}\right) \geq 3\alpha^2$, or when $\alpha \in [\frac{2n}{3}, 2n]$, which is not possible when $\alpha < \frac{2}{3}$.

[7]Exceptions arise when, for instance, firms can innovate for then some degree of protection from competition may induce more innovation or more quality provision.

Therefore, as $\alpha \leq \frac{2}{3}$, all teams are in the fringe and choose NVI. The equilibrium price solves $p = \alpha\left(1 - \frac{p}{2}\right)$. Therefore $p = \frac{2\alpha}{2+\alpha}$ and the surplus of a team is equal to $\frac{3\alpha^2}{2(2+\alpha)^2}$.

If a full-monopoly forms, ignoring the NFR constraint, the monopoly produces $\frac{1}{2}$, and the monopoly price $\frac{\alpha}{2}$ is inferior to the competitive price $\frac{2\alpha}{2+\alpha}$. While pro-competitive, a monopoly cannot be an equilibrium structure because NFR is violated.

Barriers to access ($\sigma < 1$). However, if teams face barriers in the fringe but large firms do not, a move towards oligopoly can satisfy NFR and increase the consumer surplus *but also* the teams' surplus with respect to a situation without entry barriers. To illustrate this possibility, suppose that teams have a probability $\sigma < 1$ of entering in the fringe. If a full-monopoly forms and sets a price $1/2$, the NFR condition is satisfied if $v(1,1;\alpha) \geq \sigma v_f(1,1;\alpha)$, that is if $\frac{2\alpha-1}{8} \geq \sigma\frac{3\alpha^2}{32}$, or

$$\sigma \leq \frac{4}{3}\frac{2\alpha - 1}{\alpha^2}.$$

Therefore, as long as $\alpha \in [1/2, 2/3)$, there exists an access barrier σ that will lead to a monopoly equilibrium structure and a lower equilibrium price than in its absence. Hence consumers gain when σ is low, but teams lose. Nonetheless, this provides a rationale, at least in poor or depressed economies, for licensing regulation or lax antitrust enforcement.

It is worth remarking that if α is very low (specifically, less than $1/2$), it is not possible for an oligopoly to exist. Indeed, a necessary condition for teams to participate in the oligopoly is that their surplus is non-negative. A full n-oligopoly generates a surplus of $\frac{n^2}{(n+1)^2}\left(\frac{\alpha}{n} - \frac{1}{2}\right)$ which is positive when $n \leq 2\alpha$ but this is less than 1 if $\alpha < 1/2$. Thus for very low levels of demand, the industry is caught, whether or not there are entry barriers, into a low-productivity trap, where all teams produce the NVI quantity. (The NVI total quantity is $\frac{p}{4}$, and p solves $p = \alpha(1 - p/4)$ or $p = \frac{4\alpha}{4+\alpha}$.)

6.2 Variable Input

Suppose that teams can increase their productive capacity by purchasing an input z at (monetary) cost wz. More use of inputs reduces the quiet life of teams, and we assume that the private costs of U and D are also multiplicative in the use of inputs z. A unit of input produces $q(z) = \sqrt{z}$ output, hence the (monetary) cost of a unit of output q is wq^2 and the private costs are q^2u^2 and q^2d^2 respectively.

Consider the problem of an HQ of a fringe team anticipating a market price p. She chooses q, u, d to maximize

$$pq \min(1, u + d) - wq^2$$

and clearly, choosing $u = d = \frac{1}{2}$ is profit maximizing. Likewise, if the HQ of a Cournot firm chooses q, u, d for each team, the expected output is $\frac{\mu}{n}(u + d)y$ while the cost is $w\frac{\mu}{n}q^2$, and it is cost minimizing to choose $u = d = \frac{1}{2}$. Therefore a team subject to the authority of an HQ has a private cost of $\frac{1}{2}$ per unit of input, whether or not it is part of a firm.

However, as before, when demand is high and teams choose VI in the fringe, firms produce less per team than a team in the fringe: this is the usual quantity reduction of a firm with market power. Therefore, teams will still have a quieter life in firms than in the fringe.

Consider an oligopoly $(n, 1)$. Each fringe firm maximizes $pq - wq^2$ and has a supply curve $q(p) = \frac{p}{2w}$. From above, restricting attention to a demand function $P = \alpha - Q\sigma$, the quantity produced by a firm in a full n-oligopoly is

$$q(n; w) := \frac{\alpha\sigma}{n + 1 + 2w\sigma}$$

while the market price is

$$p(n; w) := \frac{\alpha(2w\sigma + 1)}{2w\sigma + n + 1}.$$

If a team is in the fringe, HQ chooses $q = \frac{p}{2w}$, and the surplus is equal to $v_f^I = \frac{p^2}{4w} - \frac{p^2}{8w^2}$.

It follows that the teams' surplus in oligopolies firms is

$$v(n, \beta, w) = \frac{n\alpha^2\sigma(2(w\sigma + 1 - n)}{2(2w\sigma + 1 + n)^2}$$

while the surplus of a team in the fringe is

$$v_f(n, \sigma, w) = \frac{(-1 + 2w)\alpha^2(2w\sigma + 1)^2)}{8w^2(2w\sigma + 1 + n)^2}$$

If $w > 1/2$, the hold-out effect is present. As illustrated in figure 3 the smallest and largest solutions for a full oligopoly are increasing functions of $\beta := 1/\sigma$, generalizing the result that an increase in market size is a force towards more concentration.[8]

[8]The solutions are $\underline{n} = \frac{8w^3\sigma + 8w^2 \pm \sqrt{((8w^3\sigma + 8w^2)^2 + 16w^2(4w^2\sigma^2 - 8w^3\sigma^2 + 4w\sigma - 8w^2\sigma + 1 - 2w)}}{8w^3\sigma}$ and are decreasing functions of σ. The bounds are also increasing in w.

The bounds are also increasing in w. Hence, increases in the price of input is a force towards less concentration.

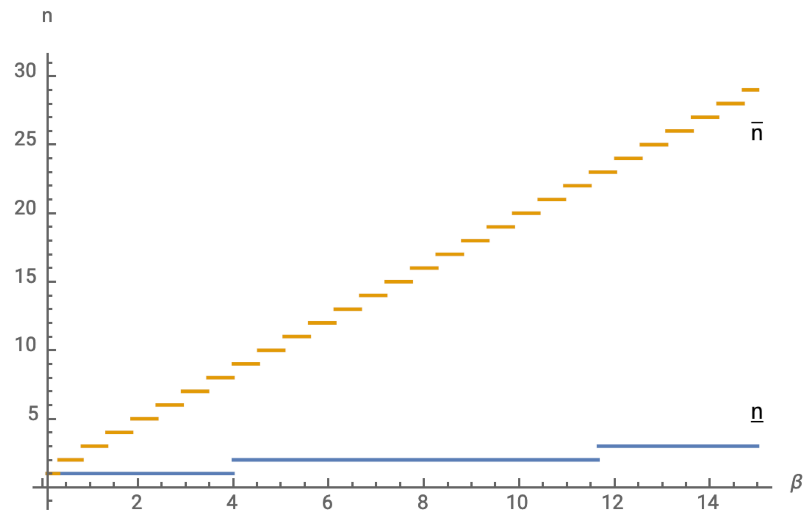


Figure 3: Bounds on Market Structure (full oligopolies and $w = 1$)

A Appendix

A.1 Proofs Missing from the Text

Proof of Claim 1

Let $\hat{n} > n$ but assume that $q(\hat{n}) > q(n)$. Then, necessarily $\hat{n}q(\hat{n}) > nq(n)$ and we have the inequalities

$$q(\hat{n}) > q(n) = -\frac{P(nq(n))}{P'(nq(n))} > -\frac{P(\hat{n}q(\hat{n}))}{P'(\hat{n}q(\hat{n}))} = q(\hat{n})$$

which is a contradiction. Now, since $q(\hat{n}) < q(n)$, we have

$$-\frac{P(\hat{n}q(\hat{n}))}{P'(\hat{\hat{n}}q(\hat{n}))} = q(\hat{n}) < q(n) = -\frac{P(nq(n))}{P'(nq(n))}$$

and our assumption implies that $\hat{n}q(\hat{n}) > nq(n)$.

Proof of Proposition 2

It is sufficient to show that the team surplus $v(n, 1)$ is decreasing in n. Let $x(n) := nq(n)$; as we have already seen, Assumption 1 implies that $x(n)$ is an increasing function of n. The surplus of a team is then $\sigma(n) := P(x(n))x(n) - \frac{x(n)^2}{2}$. Differentiating with respect to n yields

$$\begin{aligned}
\sigma'(n) &= x'(n)\left(x(n)P'(x(n)) + P(x(n)) - x(n)\right) \\
&= x'(n)\left(\frac{x(n)}{n}P'(x(n)) + P(x(n)) - x(n) + \frac{n-1}{n}x(n)P'(x(n))\right) \\
&= x'(n)\left(-x(n) + \frac{n-1}{n}x(n)P'(x(n))\right) \\
&< 0.
\end{aligned}$$

the third equality follows the best response property of $q(n)$, and the inequality follows $x(n)$ increasing and decreasing demand.

Proof of Corollary 1

It is sufficient to show that the slope $dn/d\mu$ of the isosurplus curves are (1) steeper than the slope of the No Free Riding Constraint when the two curves intersect and (2) are positively sloped.

The significance of this observation is that in the absence of integer constraints, team optimal allocations have $\mu = 1$ and are unique. With integer constraints, of course, $\mu < 1$ may be optimal, but the optimum is unique except on a zero-measure set, where there can be two solutions (N, μ) and $(N+1, 1)$.

We continue to assume that the inverse demand satisfies log-concavity: $P'' \leq \frac{P'^2}{P}$ and consider situations where demand is large that is when $v_f(n, \mu) = p(n, \mu) - \frac{1}{2}$.

The slope of the isosurplus $v(n, \mu) = v_0$ is $\frac{dn}{d\mu} = \frac{-v_\mu}{v_n}$, while that of the constraint $v(n, \mu) - p(n, \mu) + \frac{1}{2} = 0$ is $\frac{dn}{d\mu} = \frac{p_\mu - v_\mu}{v_n - p_n}$. At all optima in which the constraint binds and there is a meaningful oligopoly, we must have the intensity $x < 1$.

1. We first note that $v_n < 0 < v_n - p_n$ along the constraint.

   (a) To see this, first observe that by differentiating the Cournot equilibrium condition $\mu x P' + nP = 0$, one obtains

   $$x_n = \frac{-P/\mu}{\mu x P'' + (n+1)P'} > 0,$$

   as the denominator is negative: from log concavity, the denominator is bounded above by $\frac{\mu x P'^2}{P} + (n+1)P'$, which is negative iff $\mu x P' + (n+1)P > 0$. But that follows from the equilibrium condition $\mu x P' + nP = 0$ and $P > 0$.

(b) We have $v_n = p_n x + (P - x)x_n$. The constraint $Px - \frac{1}{2}x^2 = P - \frac{1}{2}$ is equivalent to $P = \frac{1}{2}(x+1)$, or $P - x = \frac{1-x}{2} > 0$. Then $v_n - p_n = (1 - x)(\frac{x_n}{2} - p_n) > 0$ (note $p_n = \mu x_n P' < 0$). Meanwhile $v_n = p_n x + (P-x)x_n = (\mu x P' + P)x_n - x x_n$. From the equilibrium condition $\mu x P' + nP = 0$, $(\mu x P' + P)x_n \leq 0$ for all $n \geq 1$ and therefore $v_n < 0$.

2. Given the above, the condition

$$\frac{-v_\mu}{v_n} > \frac{p_\mu - v_\mu}{v_n - p_n}$$

is equivalent to

$$-v_n v_\mu + p_n v_\mu < -v_\mu v_n + p_\mu v_n$$

or

$$(p_\mu x + (P - x)x_\mu)p_n < (p_n x + (P - x)x_n)p_\mu.$$

3. Since along the binding constraint $P - x = (1 - x)/2 > 0$, this reduces to $p_n x_\mu < p_\mu x_n$. Substituting $p_n = \mu x_n P'$, and $p_\mu = (x - 1 + \mu x_\mu)P'$ renders the last inequality as

$$0 < (x - 1)P' x_n,$$

which, because $1 - x > 0 > P'$ and $x_n > 0$, is always satisfied. This establishes (1).

For (2), we need only show that $v_\mu > 0$; then since $v_n < 0$, isosurplus curves are upward sloping.

$$v_\mu = P_\mu x + (P - x)x_\mu P_\mu = (x - 1 + \mu x_\mu)P'$$

So

$$\mu v_\mu = \mu x(x - 1)P' + [\mu x P' + (P - x)]\mu x_\mu$$

Since $\mu x P' + nP = 0$ in Cournot equilibrium, the term in brackets is negative. Differentiating the Cournot equilibrium condition to obtain x_μ, we find

$$\mu x_\mu = \frac{(1 - x)\mu x P'' + ((1 - x)n - x)P'}{\mu x P'' + (n + 1)P'}$$

Observe from this that

$$\mu x_\mu = 1 - x - \frac{P'}{\mu x P'' + (n+1)P'},$$

and therefore

$$\begin{aligned}\mu v_\mu =& \mu x(x-1)P' + [\mu x P' + (P-x)]\mu x_\mu \\ =& \mu x(x-1)P' + [\mu x P' + (P-x)][1 - x - \frac{P'}{\mu x P'' + (n+1)P'}] \\ =& (1-x)(P-x) - \frac{[\mu x P' + (P-x)]P'}{\mu x P'' + (n+1)P'}.\end{aligned}$$

The second term of the last line is positive, since as already noted, $\mu x P' + (P - x)$, $\mu x P'' + (n+1)P'$, and P' are negative. Thus $\mu v_\mu > 0$ if $P \geq x$, which is certainly true along the constraint. We now show it is true at any candidate for an optimum. TBC...

Proof of Lemma 4

Because (n, μ) is the equilibrium before the shock, it must be the case that the NFR constraint binds, that is $v(n, \mu) = v_f(n, \mu)$ *and* that it is not possible to increase μ without violating this constraint. In other words, the graph of $v(n, \mu)$ must intersect the graph of $v_f(n, \mu)$ from below.

Suppose first that $P(n(q(n, \mu)) + 1 - \mu) > 2/3$, hence that fringe firms choose VI. Consider an increase in market size $S > 1$, and assume that this change can be made arbitrarily small. Consider the first order condition of the firms in an oligopoly $(n, \hat{\mu})$ when the market size is σ:

$$\frac{q(n, \hat{\mu}; \sigma)}{\sigma} = \rho \left(\frac{nq(n, \hat{\mu}; \sigma) + 1 - \hat{\mu}}{\sigma} \right).$$

It is then clear that if $1 - \hat{\mu} = \sigma(1 - \mu)$, $\frac{q(n, \hat{\mu}; \sigma)}{\sigma} = q(n, \mu)$ and the market price is the same after the shock if the market structure is $(n, \hat{\mu})$ than before the shock with the structure (n, μ). Now, since the price is unchanged, $v_f(n, \hat{\mu}; \sigma) = v_f(n, \mu)$. But the surplus of teams in the firm increases. Indeed, for a *fixed price*, the surplus before the shock is

$$P \frac{n}{\mu} q(n, \mu) - \frac{\left(\frac{n}{\mu} q(n, \mu) \right)^2}{2}$$

while after the shock it is

$$P\frac{nq(n,\hat{\mu};\sigma)}{\hat{\mu}}-\frac{\left(\frac{n}{\hat{\mu}}q(n,\hat{\mu};\sigma)\right)^2}{2}=P\frac{\sigma}{1-\sigma(1-\mu)}nq(n,\mu)-\frac{S^2}{(1-S(1-\mu))^2}\frac{Nq(n,\mu)^2}{2}$$

The function $Pax-a^2\frac{x^2}{2}$ has variation with respect to a equal to $Px-ax^2$ and is positive if $a\leq 1/2$ and $x=Nq(n,\mu)$. Indeed, if $a<1/2$, the variation is greater than $Px-\frac{x^2}{2}$ which is positive at $x=Nq(n,\mu$ by NFR. Taking $a=\frac{\sigma}{1-\sigma(1-\mu)}$, the condition $a<1/2$ reduces to $\sigma<\frac{1}{3-\mu}$ which can always be satisfied for small shocks.

Now, in the market structure $(n,\hat{\mu})$ and after the shock σ, the surplus of teams in firms is greater than before (because the surplus function v is increasing in σ) while the surplus of teams is the same as before (because the price does not change.) Hence the NFR condition holds strictly. It is therefore possible to increase μ even further until the NFR condition holds. This is possible because by assumption, as σ is close to 1, $v(n,1)<v_f(n,1)$ for otherwise the full oligopoly would have been an equilibrium before the shock.

The same argument applies if the initial equilibrium market price is less than 2/3 and $q_f(n,\mu)$ solves the

$$q_f(n,\mu)=(1-\mu)\frac{P(nq(n,\mu)+q_f(n,\mu)}{2}.$$

In this case, choosing as before $\hat{\mu}>\mu$ such that

$$\frac{1-\hat{\mu}}{S}=1-\mu$$

insures that the price is unchanged. Indeed, fringe firms have outside option $\frac{P^2}{4}$ as before and produce $\frac{P}{2}$ each, implying that the fringe production is $\frac{(1-\hat{\mu})P}{2}$, and therefore the first order condition of firms is

$$\frac{q(n,\hat{\mu})}{\sigma}=\rho\left(\frac{q(n,\hat{\mu};\sigma)}{\sigma}+\frac{(1-\hat{\mu})P}{2\sigma}\right)$$

and, as before, $q(n,\hat{\mu};v)=Sq(n,\mu)$. The rest of the argument mimics the previous case.

A.2 Rationalizing the Stable Structures

TBC

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