MECS 570-1: Organizational Economics I

Michael Powell

Competition and Managerial Incentives

Competition and Organization

In much of the course, we focus on how exogenous external factors shape firm-level organization decisions. In our discussion of incentives, we took as given the contracting space and the information structure and derived the optimal action that the firm wants the agent to take as well as the contract designed to get him to do so. Later, when we discuss firm boundaries, we will again take as given the contracting space (which will necessarily be less complete than the parties would prefer) and other characteristics of the firm's environment (such as the returns to managers' investments, costs of adapting to unforeseen contingencies, and the informativeness of manipulable public signals) and derive optimal control-rights allocations and other complementary organizational variables. In this lecture, we will look at how external factors shape firm-level organization decisions *through their effects on product-market competition and the price mechanism*. We will begin with the treatment of a classic topic: the effects of product-market competition on managerial incentives. We will then discuss the interplay between relational incentive contracts and the competitive environment, and after our discussion of firm boundaries, we will return to look at the interplay between firm boundaries and the competitive environment. We will be interested in particular in the question of how the firms' competitive environment and firm-level productivity interact.

Competition and Managerial Incentives

The claim that intense product-market competition disciplines firms and forces them to be more productive seems straightforward and obviously true. Hicks (1935) described this intuition evocatively as "The best of all monopoly profits is a quiet life." (p. 8) Product-market competition requires firm owners and firm managers to work hard to remove slack (or as

Leibenstein (1966) describes it, "X-inefficiency") from their production processes in order to survive. In addition, recent empirical work (Backus, 2014) suggests that the observed correlation between competition and productivity is driven by within-firm productivity improvements in more-competitive environments. As straightforward as this claim may seem, it has been remarkably problematic to provide conditions under which it holds. In this section, I will sketch a high-level outline of a model that nests many of the examples from the literature, and I will hopefully provide some intuition about why this claim has been difficult to pin down.

There are $N \geq 1$ firms that compete in the product market. In what follows, I will look at monopoly markets ($N = 1$) and duopoly markets ($N = 2$), and I will focus on the incentives a single firm has to reduce its marginal costs. Firms are ex ante identical and can produce output at a constant marginal cost of c. Prior to competing in the product market, firm 1 can reduce its marginal cost of production to $c - e$ at cost $C_1(e)$ for $e \in E = [0, c]$. Given e, firm 1 earns gross profits $\pi_1(e)$ on the product market. Firm 1 therefore chooses e^* to solve

$$\max_e \pi_1(e) - C_1(e),$$

and the ultimate question in this literature is: when does an increase in product-market competition lead to an increase in e^*?

As you might expect, the reason why this question is difficult to answer at such a high level is that it is not clear what "an increase in product-market competition" *is*. And different papers in this literature present largely different notions of what it means for one product market to be more competitive than another. Further, some papers (Hart, 1983; Scharfstein, 1988; Hermalin, 1992; Schmidt, 1997) focus specifically on how product-market competition affects the *costs* of implementing different effort levels, $C_1(e)$, while others (Raith, 2003; Vives, 2008) focus on how product-market competition affects the *benefits* of implementing different effort levels, $\pi_1(e)$.

To see how these fit together, note that we can define firm 1's *product-market problem* as

$$\pi_1(e) = \max_{p_1} (p_1 - (c - e))\, q_1(p_1),$$

where $q_1(p_1)$ is either the market demand curve if $N = 1$ or, if $N = 2$, firm 1's residual demand curve given firm 2's equilibrium choice of its competitive variable. Throughout, we will assume that for any e, there is a unique Nash equilibrium of the product-market competition game. Otherwise, we would have to choose (and, importantly, justify) a particular equilibrium-selection rule.

If the firm's manager is its owner, $C_1(e)$ captures the effort costs associated with reducing the firm's marginal costs. If the firm's manager is not its owner, $C_1(e)$ additionally captures the agency costs associated with getting the manager to choose effort level e. Let $W \subset \{w : Y \to \mathbb{R}\}$, where $y \in Y$ is a contractible outcome. As we described in our discussion of incentives, the case where the firm's manager is its owner can be captured by a model in which $Y = E$, so that effort is directly contractible. Under this formulation, we can define firm 1's *agency problem* as

$$C_1(e) = \min_{w \in W} \int w(y)\, dF(y|\, e)$$

subject to

$$\int u(w(y) - c(e))\, dF(y|\, e) \geq \int u(w(y) - c(e'))\, dF(y|\, e')$$

for all $e' \in E$. In the remarks below, I provide expressions for $C_1(e)$ for the three elemental models we discussed in the first two lectures.

We can now see that the original problem,

$$\max_e \pi_1(e) - C_1(e),$$

which looked simple, actually masks a great deal of complication. In particular, it is an optimization problem built upon two sub-problems, and so the question then is how changes in competition affect either or both of these sub-problems. Despite these complications, we can still make some progress.

In particular, focusing on the benefits side, we can apply the envelope theorem to the product-market competition problem to get

$$\pi_1' (e) = q_1^* (e),$$

where $q_1^* (e) = q_1 (p_1^* (e))$, and again, we can write

$$q_1^* (e) = q_1^* (0) + \int_0^e \frac{dq_1^* (s)}{ds} ds = q_1^* (0) + \int_0^e \eta_1^* (s) \, ds,$$

where $\eta_1^* (\cdot)$ is the quantity pass-through of firm 1's residual demand curve. That is, $\eta_1^* (e) = q_1' (p_1^* (e)) \rho (e)$, where $\rho (e)$ is the pass-through of firm 1's residual demand curve:

$$\rho (e) = -\frac{1}{1 - (q (p_1^* (e)) / q_1' (p_1^* (e)))'}.$$

See Weyl and Fabinger (2013) for an excellent discussion on the role of pass-through for many comparative statics in industrial organization. Further, we can write

$$\begin{aligned} \pi_1 (e) &= \pi_1 (0) + \int_0^e q_1^* (s) \, ds = \pi_1 (0) + \int_0^e \left[q_1^* (0) + \int_0^t \eta_1^* (s) \, ds \right] dt \\ &= \pi_1 (0) + e q_1^* (0) + \int_0^e (e - s) \, \eta_1^* (s) \, ds, \end{aligned}$$

where the last equality can be derived by integrating by parts.

Next, for the three elemental models of incentives we discussed in the first week of class, we can derive explicit expressions for $C_1 (e)$, which I do in the remarks below.

Remark 1 (Limited Liability) *Suppose* $Y = \{0, 1\}$, $\Pr [y = 1 | e] = e$, $c (e) = \frac{c}{2} e^2$, $W =$

$\{w : Y \to \mathbb{R} : w(1) \geq w(0) \geq 0\}$, $u(x - c(e)) = x - c(e)$, *and* $\bar{u} = 0$. *Then*

$$C_1(e) = c(e) + R(e),$$

where $R(e) = ce$ *are the incentive rents that must be provided to the agent to induce him to choose effort level* e.

Remark 2 (Risk-Incentives) *Suppose* $Y = \mathbb{R}$, $y = e + \varepsilon$, $\varepsilon \sim N(0, \sigma^2)$, $c(e)$ *is increasing, convex, and differentiable,* $W = \{w : Y \to \mathbb{R} : w(y) = s + by, s, b \in \mathbb{R}\}$, *and* $u(x - c(e)) = -\exp\{-r[x - c(e)]\}$, *and* $\bar{u} = 0$. *Then*

$$C_1(e) = c(e) + r(e),$$

where $r(e) = \frac{1}{2} r \sigma^2 e^2$ *is the risk premium that the agent must be paid in order to provide him with strong enough incentives to choose effort level* e.

Remark 3 (Misalignment) *Suppose* $Y = \{0, 1\}$, $\Pr[y = 1 | e_1, e_2] = f_1 e_1 + f_2 e_2 \equiv e$, $P = \{0, 1\}$, $\Pr[p = 1 | e_1, e_2] = g_1 e_1 + g_2 e_2$, $c(e_1, e_2) = \frac{1}{2}(e_1^2 + e_2^2)$, $W = \{w : P \to \mathbb{R}\}$, *and* $u(x - c(e_1, e_2)) = x - c(e_1, e_2)$, *and* $\bar{u} = 0$. *Then*

$$C_1(e) = c(e) + m(e),$$

where $m(e) = \frac{1}{2}(\tan\theta)^2 e^2$, *where* $\tan\theta$ *is the tangent of the angle between* (f_1, f_2) *and* (g_1, g_2). *If* $(f_1, f_2) \neq (g_1, g_2)$, *in order to get the agent to choose a particular probability of high output,* e, *the principal has to provide him with incentives that send him off in the "wrong direction," which implies that his effort costs are higher than they would be if* $(f_1, f_2) = (g_1, g_2)$, *which the principal must compensate the agent for.* $m(e)$ *represents the costs due to the misalignment of the performance measure. If* $(f_1, f_2) = (g_1, g_2)$, *then* $\tan\theta = 0$. *If* $(f_1, f_2) \perp (g_1, g_2)$, *then* $\tan\theta = \infty$.

If we restrict attention to one of the three elemental models of incentive provision described in the remark above, we have:

$$C_1(e) = c(e) + R(e) + r(e) + m(e),$$

so that the original problem can now be written as

$$\max_e eq_1^*(0) + \int_0^e (e-s)\,\eta_1^*(s)\,ds - c(e) - R(e) - r(e) - m(e).$$

We therefore have that $q_1^*(0)$, $\eta_1^*(\cdot)$, and $c(\cdot)+R(\cdot)+r(\cdot)+m(\cdot)$ constitutes a set of *sufficient statistics* for firm 1's product-market problem and its agency problem, respectively. In other words, in order to figure out what the optimal effort choice e^* by the firm is, we only need to know a couple things. First, we need to know how effort choices e map into the quantity of output the firm will sell in the product market, $q_1^*(e) = q_1^*(0) + \int_0^e \eta_1^*(s)\,ds$. This schedule fully determines the *benefits* of choosing different effort levels. Second, we need to know what the expected wage bill associated with implementing effort e at minimum cost is. This schedule fully determines the *costs* to the firm of choosing different effort levels.

The motivating question then becomes: how does an increase in product-market competition affect $q_1^*(0)$, $\eta_1^*(\cdot)$, and $R(\cdot) + r(\cdot) + m(\cdot)$? (We can ignore the effects of competition on $c(\cdot)$, since the agent's cost function is usually taken to be an exogenous parameter of the model.) The point that now needs to be clarified is: what is an "increase in product-market competition?" Different papers in the literature take different approaches to addressing this point. Hart (1983), Nalebuff and Stiglitz (1983), and Scharfstein (1988) view an increase in competition as providing a firm with additional information about industry-wide cost shocks. Hermalin (1992) and Schmidt (1997) view an increase in competition as a reduction in firm profits, conditional on a given effort level by the agent. Raith (2003) and Vives (2008) view an increase in competition as either an exogenous increase in the number of competitors in a market, or if entry is endogenous, an increase in competition can be viewed as either an increase in product substitutability across firms, an increase in the market size, or a decrease in entry costs.

We are now in a position to describe the laundry list of intuitions that each of these papers provides. Going down the list, we can view Hart (1983) and Nalebuff and Stiglitz (1983) as showing that an increase in competition reduces required risk premia $r(e)$, since Principals will be able to use the additional information provided through the market price by more competition as part of an optimal contract. By Holmström's informativeness principle, since this additional information is informative about the agent's action, the risk premium necessary to induce any given effort level e is reduced. They therefore conclude that an increase in competition increases e^* because of this effect. However, as Scharfstein (1988) points out, reducing $r(e)$ is not the same as reducing $r'(e)$. In particular, the $r(\cdot)$ schedule can fall by more for lower effort levels than for higher effort levels, implying that an increase in competition could actually *reduce* effort e^*. Alternatively, one could think of competition as increasing the alignment between the contractible performance measure and the firm's objectives. In this case, an increase in competition would decrease $\tan\theta$ and therefore decrease $m'(e)$, which would in turn lead to an increase in e^*.

Hermalin (1992) emphasizes the role of negative profit shocks when the agent has some bargaining power, and there are income effects (as there would be if $u(\cdot)$ satisfied decreasing absolute risk aversion). If competition reduces firm profits, and the agent has bargaining power, then competition also reduces the agent's expected wage. This in turn makes the agent less willing to substitute out of actions that increase expected wages (i.e., high effort in this context) and into actions that increase private benefits (i.e., low effort in this context). Under this view, an increase in competition effectively reduces $r'(e)$, thereby increasing e^*.

Schmidt (1997) argues that an increase in competition increases the likelihood that the firm will go bankrupt. If an agent receives private benefits from working for the firm, and the firm is unable to capture these private benefits from the agent (say because of a limited-liability constraint), then the agent will be willing to work harder (under a given contract) following an increase in competition if working harder reduces the probability that the firm goes bankrupt. This intuition therefore implies that competition reduces $R'(e)$, the marginal incentive rents required to induce the agent to work harder. In turn, under this "increased threat of avertable bankruptcy risk," competition can lead to an increase in e^*.

In each of these papers so far, the emphasis has been on how an increase in competition impacts marginal agency costs: $R'(e) + r'(e) + m'(e)$ and therefore how it impacts the difference between what the firm would like the agent to do (i.e., the first-best effort level) and what the firm optimally gets the agent to do (i.e., the second-best effort level). However, putting agency costs aside, it is not necessarily clear how an increase in competition affects the firm's *first-best* level of effort. If we ignore agency costs, the problem becomes

$$\max_e eq_1^*(0) + \int_0^e (e - s)\,\eta_1^*(s)\,ds - c(e).$$

The question is therefore: how does an increase in competition affect $q_1^*(0)$ and $\eta_1^*(e)$? Raith (2003) and Vives (2008) argue that an increase in competition affects the firm's optimal *scale of operations* (which corresponds to $q_1^*(0)$) and the firm's residual-demand elasticity (which is related to but is not the same as $\eta_1^*(e)$). In my view, these are the first-order questions that should have been the initial focus of the literature. First, develop an understanding of how an increase in competition affects what the firm would like the agent to do; *then*, think about how an increase in competition affects what the firm optimally gets the agent to do.

Raith (2003) provides two sets of results in a model of spatial competition. First, he shows that an exogenous increase in the number of competitors reduces $q_1^*(e)$ for each e and therefore always reduces e^*. He then shows that, in a model with endogenous firm entry, an increase in parameters that foster additional competition affects e^* in different ways, because they affect $q_1^*(e)$ in different ways. An increase in product substitutability has the effect of reducing the profitability of the industry and therefore reduces entry into the industry. Raith assumes that the market is covered, so aggregate sales remain the same. This reduction in the number of competitors therefore increases $q_1^*(e)$ for each e and therefore increases e^*. An increase in the market size leads to an increase in the profitability of the industry and therefore an increase in entry. However, the increased entry does not (under the functional forms he assumes) fully offset the increased market size, so $q_1^*(e)$ nevertheless increases for each e, and therefore an increase in market size increases e^*. A reduction in entry costs, however, leads to an increase in firm entry, reducing the sales per firm ($q_1^*(e)$) and therefore reduces e^*.

Raith's results are intuitively plausible and insightful in part because they focus on the $q_1^*(\cdot)$ schedule, which is indeed the appropriate sufficient statistic for the firm's problem absent agency costs. However, his results are derived under a particular market structure, so a natural question to ask is whether they are also relevant under alternative models of product-market competition. This is the question that Vives (2008) addresses. In particular, he shows that while some of the effects that Raith finds do indeed depend on his assumptions about the nature of product-market competition, most of them hold under alternative market structures as well. His analysis focuses on the scale effect (i.e., how does an increase in competition affect $q_1^*(0)$) and the elasticity effect (i.e., how does an increase in competition affect the elasticity of firm 1's residual demand curve?), but as pointed out above, the latter effect should be replaced with a quantity pass-through effect (i.e., how does an increase in competition affect the quantity pass-through of firm 1's residual demand curve?)

To illustrate how competition could affect the quantity pass-through in different ways depending on the nature of competition, suppose there are two firms, and the market demand curve is $D(p) = A - Bp$. This market demand curve is a constant quantity pass-through demand curve $\eta(p) = B/2$. Suppose firms compete by choosing supply functions, and firm 2 chooses supply functions of the form $S_2(p) = a_2 + b_2 p$. An increase in a_2 or an increase in b_2 can be viewed as an aggressive move by firm 2. I will think of an increase in either of these parameters as an increase in competition. Given firm 2 chooses supply function

$S_2(p) = a_2 + b_2 p$, firm 1's residual demand curve is $q_1(p) = \tilde{A} - \tilde{B}p$, where $\tilde{A} = A - a_2$ and $\tilde{B} = B + b_2$. The quantity pass-through of firm 1's residual demand curve is

$$\eta_1(p) = \frac{B + b_2}{2}.$$

Firm 1 solves

$$\max_p (p - (c - e))\, q_1(p),$$

which yields the solution

$$\begin{aligned} p^*(e) &= \frac{\tilde{A}}{2\tilde{B}} + \frac{1}{2}(c - e) \\ q_1(p^*(e)) &= \underbrace{\frac{\tilde{A} - \tilde{B}c}{2}}_{q(p^*(0))} + \int_0^e \underbrace{\frac{\tilde{B}}{2}}_{\eta_1^*(s)} ds. \end{aligned}$$

Two polar forms of competition will highlight the key differences I want to stress. The first form of competition I will consider is standard *Cournot competition*, in which firm 2 chooses supply function parameter a_2 and fixes $b_2 = 0$. A higher value of a_2 is a more aggressive move by firm 2, and we can see that

$$q_1(p^*(e)) = \frac{A - Bc}{2} - \frac{a_2}{2} + \int_0^e \frac{B}{2} ds.$$

If we interpret an increase in competition as a more aggressive move by firm 1's competition, then an increase in competition decreases $q_1(p^*(e))$ for all e, which in turn implies a decrease in firm 1's optimal choice e^*.

The other form of competition I will consider is *rotation competition*, in which firm 2 chooses supply function parameters a_2 and b_2 such that $(A - a_2 - (B + b_2)c)$ is held constant. That is, firm 2 can only choose a_2 and b_2 such that $a_2 + b_2 c = 0$. Firm 2 therefore chooses b_2, which yields a supply function $S_2(p) = b_2(p - c)$. A higher value of b_2 is a more aggressive move by firm 2. Further we can see that

$$q_1\left(p^*\left(e\right)\right) = \frac{A - Bc}{2} + \int_0^e \frac{B + b_2}{2} ds.$$

In this case, an increase in competition increases the quantity pass-through of firm 1's residual demand curve and therefore increases $q_1\left(p^*\left(e\right)\right)$ for all e, which in turn implies an increase in e^*.