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Job assignment, market power and managerial incentives

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ABSTRACT

I study how product market conditions determine labor market outcomes in an economy where a continuum of heterogeneous firms compete for heterogeneous managers. The main objective of the paper is to establish how market power and managerial talent influence the incentive contracts. If firms with higher (lower) market power benefit more from managerial actions, then managerial talent has greater effects in such firms, and hence more talented managers are lured into firms with higher (lower) market power following a positively (negatively) assortative matching pattern. The equilibrium relationship between market power and managerial incentives is monotone if and only if the equilibrium matching is monotone.

1. Introduction

Since Leibenstein's (1966) theory of *X-inefficiency*, a plethora of theoretical works, using agency models, have analyzed how product market competition affects managerial incentives within a firm (e.g. Hart, 1983; Hermalin, 1992; Raith, 2003; Scharfstein, 1988; Schmidt, 1997). Many empirical works support the view that increased product market competition, which may be measured by various fundamentals of the market, induces firms to elicit greater managerial effort by providing stronger incentives (e.g. Cuñat & Guadalupe, 2005; Karuna, 2007; Kole & Lehn, 1997; Nickell, 1996; Palia, 2000). On the other hand, Aggarwal and Samwick (1999) and Beiner, Schmid, and Wanzenried (2011) find a negative relationship between the degree of product market competition and managerial incentives. Although there is an apparent consensus of empirical studies regarding a monotone relationship between managerial incentives and product market competition, most of the theoretical predictions about such association have been ambiguous simply because competition affects the organizational structure of a firm via different channels which may not always point in the same direction.

The main objective of the present paper is two-fold. First, it aims at providing a unified framework that determines the level as well as the incentive structure of the executive compensation packages. I argue that this cannot be achieved using a standard agency model that involves only one firm and one manager. Second, the model intends to offer unambiguous predictions about the effects of market power or product market competition on managerial efforts and incentives. To this end, I analyze a matching market where heterogeneous managerial talent is assigned to firms which differ in market power. This approach allows to establish a one-to-one relationship between market power and managerial incentives. A manager's principal task is to undertake value enhancing non-verifiable actions such as effort, investment, etc. Due to non-verifiability, a moral hazard problem arises in the choice of actions. It is shown that the firms which benefit more from managerial actions lure more talented managers. A sorting or matching effect determines completely the equilibrium incentives, and hence managerial efforts and incentives are monotone with respect to market power whenever the equilibrium matching is monotone. I also analyze various sources of market power such as market size, price cap regulation, cost efficiency under which variation in market power has differential implications for incentives.

The literature on competition and managerial incentives in general takes the degree of product market competition as the determinant of managerial incentives. In the present model, each

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firm represents one distinct market, and hence greater intensity of competition is equivalent to lower market power. The phrase "more market power" or "less intense competition" may have many interpretations. First, in a strategic environment, number of firms, degree of product substitutability, cost of entry, etc. per se are appropriate measures of market power or competition. The present paper abstracts from strategic considerations. Following Novshek (1980), a second interpretation is that more competition means a closer approximation to perfect competition, i.e., a lower price-cost margin. In this paper, I take the second approach. In Section 4, I discuss various sources of market power, and show how the results derived in the theoretical model depend on these sources.

At this juncture, it is worth analyzing the ambiguous predictions the extant theoretical literature has provided in regard to the relationship between competition and managerial incentives. Different models have analyzed different channels through which product market fundamentals affect the incentive structure of executive pay. Hart (1983) identifies an *information effect* which asserts that greater product market competition facilitates the owner of a firm to distinguish aggregate from idiosyncratic shocks, and reduces the cost of incentives, and hence competition unambiguously improves managerial incentives. Scharfstein (1988) argues that Hart's (1983) result crucially depends on the specification of discontinuous preferences of the manager over income, and the result can be reversed under continuous preferences. Hermalin (1992) identifies three countervailing effects. When more stringent competition implies lower expected profit, the managers tend to consume fewer "agency goods" since they typically receive a share of firms' profit, which is the positive *income effect*. Second, the inherent riskiness of a firm varies with the competitive environment it operates in, and so does the actions of a CEO if he is not risk neutral. Higher volatility of firm's profit may thus result in lower managerial effort, which is the *risk-adjustment effect*. Finally, competition may change the difference in expected profits associated with different actions taken by a manager, which is the *change-in-the-relative-value-of-actions effect*, which is same as the 'value of managerial actions' effect in the current paper. If the marginal value of a 'better' action, say managerial effort is increasing (decreasing) with respect to the degree of product market competition, then greater competition leads to stronger (weaker) managerial incentives. Thus, the overall effect of competition on managerial effort is ambiguous. Schmidt (1997) also identifies two countervailing effects. The *value-of-cost-reduction effect* is the same as the third effect in Hermalin (1992). In addition to that, there is a *threat-of-liquidation effect* which asserts that greater product market competition implies that a firm is more likely to go bankrupt, and hence to avoid liquidation of the firm the manager tends to work harder since liquidation implies a loss of his reputation. Raith (2003) considers a model with risk averse managers and free entry under price competition in a Salop circle. A more competitive market is characterized by lower entry costs, since it induces a higher number of firms in equilibrium. Raith (2003) finds that competition increases managerial incentives. In the present paper, I abstract from all but one of the aforementioned effects, and concentrate on the 'value of managerial actions' effect, and show how this effect influences managerial incentives via an endogenous firm–manager matching.

Recent empirical literature (e.g. Ackerberg & Botticini, 2002; Chiappori & Salanié, 2003) on incentive contracting claims that endogenous principal–agent matching is an important determinant of optimal contracts in the principal–agent relationships. Ackerberg and Botticini (2002) argues that in order to study the effects of observed principal and agent characteristics on optimal contracts, empirical models typically regress contract choice on these parameters. They show that when there are incentives whereby principals of given types end up hiring agents of particular types, the estimated coefficients of a simple regression on the observed characteristics may be misleading. To understand this point in the current context, suppose that there are two types of managers (high and low talent), and two types of firms (high and low market power). Standard agency models (with one firm and one manager) would predict weaker incentives (measured in terms of bonuses) for the more talented managers since it is relatively easier to incentivize them to exert high effort. Now suppose that the bonus offered by each firm is a proportion of the additional profit generated by cost reduction, and that this marginal profit is higher in firms with high market power. This would induce such firms to hire the more talented managers by offering stronger incentives. Hence, stronger incentives will be associated with high talent. Therefore, the outcome of a talent assignment model will give prediction about the relationship between talent and incentives which is exactly opposite to what would have been predicted by the standard agency theory.

Two papers closely related to the current work are Barros and Macho-Stadler (1998), and Wright (2003). In Barros and Macho-Stadler (1998), talent affects the profitability of the firm the manager works for. Other things being equal, greater talent implies higher production. The firms differ in initial market size, and hence differences in market size implies differences in market power. Barros and Macho-Stadler show that talent has greater effect in the firm with greater market power, and hence this firm ends up hiring the more talented manager. Although it is not explicitly specified in Barros and Macho-Stadler (1998), the positive sorting between market size and managerial talent is determined by the fact that the firm with greater market size benefit more at the margin by employing the more talented manager. Wright (2003), in a more general context, considers competition among heterogeneous firms for managers who differ in their attitude towards risk, and find that less risk averse managers are lured into firms with greater marginal benefit of managerial effort. The current paper complements Wright's (2003) work by explicitly identifying the firms that have greater marginal benefit of effort under different scenarios (see Section 4). On the other hand, it generalizes Barros and Macho-Stadler (1998) by establishing that different sources of market power such as market size, price cap regulation, technological efficiency, etc. may have different implications for firm–manager assignment and managerial incentives.[1]

2. The model

2.1. Firms and managers

There are two classes of agents in the economy: a continuum $I = [0, 1]$ of risk-neutral firms and a continuum $J = [0, 1]$ of risk-neutral managers. The sets I and J are endowed with Lebesgue measure 1. Each firm is assumed to be a monopolist in the respective product market which may be justified by the presence of huge setup costs that firms require to incur to start operations. Therefore, a firm and the market where it sells its product are

[1] In contexts not related to the current one, a few other papers also incorporate moral hazard into talent assignment models in order to analyze the implications of the firm and manager characteristics for managerial incentives. Edmans, Gabaix, and Landier (2009) consider assignment of managerial talent to firm size, and show that more talented CEOs manage larger firms since talent has a greater effect in such firms. They assume that a CEO's payoff is multiplicatively separable in consumption and effort which generates empirical predictions that are different from the traditional additive models. Baranchuk, MacDonald, and Yang (2011) consider assignment of risk-averse executives to risk-neutral firms, and show that the firm size (measured by the number of divisions in a firm) is endogenously determined in equilibrium and more talented CEOs work for larger firms.

indistinguishable. The product market profit that accrues to each firm, denoted by $\pi(\theta, m)$, depends on a firm-specific idiosyncratic shock $\theta \in \Theta = \{\theta_1, \theta_2\} \subset \mathbb{R}$ with $\theta_1 < \theta_2$, and a firm- or market-specific characteristic $m \in M = [m_{\min}, m_{\max}] \subseteq \mathbb{R}_+$. I make the following assumptions on $\pi(\theta, m)$:

A1. $\Delta(m) := \pi(\theta_2, m) - \pi(\theta_1, m) > 0$ for all $m \in M$;
A2. $\pi(\theta, m) > \pi(\theta, m')$ for any $m > m'$ and for all $\theta \in \Theta$.

The first assumption asserts that θ_2 is a 'favorable shock' which enhances the profits of the firms across all markets. Let Prob . $[\theta = \theta_2] = e$ for all $m \in M$. The second assumption implies that a higher value of the market-specific parameter m increases a firm's profit at any state of the nature θ. For the purpose of the current paper, I will interpret m as 'market power' of the firm in market m, which reflects its ability to set prices above the marginal cost of production. Let $G(m)$ be the cumulative distribution of m, which denotes the fraction of firms with market power less than or equal to m. The corresponding density function is $g(m)$. I assume that $g(m) > 0$ for all $m \in M$. I also assume that a firm is not able to choose which market it belongs to, and switching between markets is prohibitively costly because of the setup costs.[2]

Shocks can be either on demand that a firm faces in a particular market, or on the cost of production. In the first case, for example, let the demand faced by a firm at a market price P is given by $D(P; \theta)$ with $D(P; \theta_2) > D(P; \theta_1)$. A particular case would be where θ represents the market size, e.g. $D(P; \theta) = \theta - P$. To illustrate the second case, let the constant average/marginal cost of production of a firm is given by $c(\theta)$ with $c(\theta_1) > c(\theta_2) \geq 0$. Given other things equal, in both cases one has $\pi(\theta_2, m) > \pi(\theta_1, m)$ for all $m \in M$.

A firm's market power m may also stem from two different sources. First, differences in various market fundamentals such as market size, market-specific regulation, price elasticity of demand imply differences market power. For example, a firm in market m, or simply a type m firm faces a linear demand function $D(p; m) = m - p$, and hence the higher the m, the greater is the firm's market size. Alternatively, consider a market-specific price cap regulation where m represents the cap. Thus, higher m (more relaxed price cap) implies greater price-cost margin. Second, market power may also be related to the efficiency of a firm's production technology, e.g. its constant marginal cost of production is given by $c = c(m)$ with $c'(m) < 0$, i.e., the higher the m, the more efficient is the firm's production technology, and hence greater is the price-cost margin. Both specifications conform to assumption A2 discussed above.[3]

Each firm hires a manager whose principal task is to take some action, e.g. effort, investment, etc. which influences the probability of the favorable shock. Without loss of generality, the probability e of state θ_2 will be interpreted as managerial action or effort. Managers differ in skill or talent, which is denoted by $q \in Q = [q_{min}, q_{max}]$ with $q_{min} > 1$. A type q manager has an effort cost function $\psi(e; q)$ which is increasing and convex in e with $\psi_{eq} < 0$ for all e and q. The higher the q, the lower is the cost that a manager entails to exert an additional unit of effort. For simplicity, and without much loss of generality, I assume the following specific form of effort cost:

$$\psi(e; q) = \frac{e^2}{2q} \quad \text{for all} \quad q \in Q.$$

Let $F(q)$ be the cumulative distribution of q, which denotes the fraction of managers with talent less than or equal to q. The corresponding density function is $f(q)$. I assume that $f(q) > 0$ for all $q \in Q$. Managerial effort is not publicly verifiable, and hence there are potential moral hazard problems in effort choice. 'Managerial effort' may include any actions that enhance firm value, and hence its interpretation is rather general than just the labor input of a manager. Therefore, I call $\Delta(m)$ the *value of managerial actions* which has been assumed to be strictly positive.

At this juncture, it is worth discussing the occupational choice of an individual in the economy. In general, a manger may not be precluded to become an entrepreneur. In this paper I make a simplifying assumption that the owners and the managers of firms form two disjoint sets of individuals, which does not imply a loss of generality so far as the type of issues the present paper wants to address. A firm may require some startup investment, and a manager may not possess any such capital. Such investment may also require specific knowledge of production technology which the owner is unable to transfer which prohibits the manager to own the firm. On the other hand, managerial services are assumed to be essential to the production process as a manager may possess skills such as specialized knowledge of R&D, ability to restructure debt, etc. In principle, an entrepreneur may run a firm without hiring a manager (a self-managed firm), and exert effort by herself. I assume that this class of economic agents do not possess specific managerial skills, i.e., $q = 0$ implying that exerting effort is prohibitively costly for the owner of a firm. For example, the owner operates a subsidiary in a separate geographic market, and the manager may have to exert effort in market research and make necessary investment in order to expand the market size, which the owner cannot undertake directly.[4]

The economy last for four dates $t = 1, 2, 3, 4$. At date $t = 1$, each owner hires a manager by offering a binding state-contingent contract (z, b) where z is the base salary of the manager, and b is the bonus contingent on the favorable shock $\theta = \theta_2$. At date 2, the manager exerts non-verifiable effort e. After the realization of the random variable θ each firm sells its product in the respective product market. Finally at $t = 4$, the agreed upon payments are made. The firm–manager market is denoted by ξ.

2.2. Managerial incentives without competition for managers

In this subsection, I consider the situation where firms do not compete for managers in the labor market. In other words, managers are randomly assigned to the firms. Thus, the optimal incentive compatible contracts will be analyzed for an arbitrary firm–manager pair. When a firm of any given type m decides to hire a manager of type q, a match or partnership (m, q) is said to form. Following the formation of a partnership, the firm offers a take-it-or-leave-it contingent compensation scheme for the manager which consists of a base salary $z(m, q)$, paid in all contingencies, and a bonus $b(m, q)$, which is the incentive component of the contract, in the event when the manager succeeds in enhancing the firm's profit.[5] Denote by $s(m, q) = (z(m, q), b(m, q))$ a compensation scheme, and by $\gamma(m, q) = (e(m, q), s(m, q))$ an effort-salary combination in a given contract associated with an arbitrary match (m, q).

[2] In order to rank the firms according to a unidimensional parameter m, one only needs to compare the profits of the firms in various markets, which can be done by comparing the 'earnings per share' (EPS) or the 'margin' (profit-to-sales ratio).

[3] Section 4 analyzes various sources of market power and their implications for the equilibrium of the model.

[4] In Section 5, I discuss the implications of relaxation of such assumptions.

[5] Finiteness of the set Θ is assumed for the sake of simplicity. One could assume instead that θ is a continuous random variable taking values on $[\theta_{min}, \theta_{max}]$ with a conditional distribution function $H(\theta \mid e)$. All our results will go through if the corresponding density function $h(\theta \mid e)$ satisfies the "monotone likelihood ratio property", and the contracts are of the form $z + \beta\Delta(\theta, m)$ where z is the fixed component of the contract and $\beta\Delta(\theta, m) := \beta[\pi(\theta, m) - \pi(\theta_{min}, m)]$ for $\theta \geq \theta_{min}$ is the value of equity of the manager.

Notice that any firm would be indifferent among the managers of a given type since managers of the same type are perfect substitutes. On the other hand, a manager must be indifferent between any two firms of the same type. Thus, a contract between a firm and a manager depends only on the their types and not on individual names. For the analysis of this subsection I drop the argument (m, q) from the contract terms whenever it does not create any confusion. The above compensation scheme generates the following net expected earnings to the owner and the manager, respectively:

$$V(z, b, e) := \quad e\pi(\theta_2, m) + (1-e)\pi(\theta_1, m) - eb - z,$$

$$U(z, b, e) := \quad eb + z - \frac{e^2}{2q}.$$

An optimal incentive compatible contract or compensation scheme associated with a given match (m, q) is a solution to the following maximization problem:

$$\max_{\{z,\, b,\, e\}} \quad e\pi(\theta_2, m) + (1-e)\pi(\theta_1, m) - eb - z \quad (\mathrm{M}_1)$$

$$\text{subject to} \quad e = \operatorname{argmax}_{\hat{e}} \left\{ \hat{e}b + z - \frac{\hat{e}^2}{2q} \right\} = qb, \quad (\mathrm{IC})$$

$$z + b \geq 0, \quad (\mathrm{LL}_2)$$

$$z \geq 0, \quad (\mathrm{LL}_1)$$

$$eb + z - \frac{e^2}{2q} \geq u. \quad (\mathrm{PC})$$

The first constraint (IC) is the standard *incentive compatibility* constraint for effort choice by a manager of type q, which is a function of the base salary and bonus. Constraints (LL_1) and (LL_2) are the *limited liability* constraints which guarantee non-negative final income to the manager in each state of the nature. Constraints (IC)–(LL_2) define the set of feasible contracts and effort associated with a match (m, q). Let $\Omega(m, q)$ denote this feasible set. Finally, the constraint (PC) is the *participation* constraint of the manager which asserts that his expected payoff must be at least as high as his outside option $u \geq 0$. Denote by $\phi(m, q, u)$ the value function of the maximization problem (M_1) when the type q manager's participation constraint binds, which is given by:

$$\phi(m, q, u) = \max_{\{\gamma(m,q) \in \Omega(m,q)\}} \{V(\gamma(m, q)) \mid U(\gamma(m, q)) = u\}. \qquad (\mathrm{P})$$

The above value function represents the (constrained) Pareto frontier associated with the partnership (m, q). The following lemma characterizes the optimal managerial contract and effort when the manager's participation constraint binds.

Lemma 1. *Let $e(m, q, u)$, $b(m, q, u)$ and $z(m, q, u)$ be the optimal managerial effort, bonus and salary, respectively when the manager's participation constraint binds.*

(a) *If $u \leq (1/2)q[\Delta(m)]^2$, then the limited liability constraint of the manager binds. The optimal managerial effort and contract are given by:*

$$\begin{aligned} e(m, q, u) &= \sqrt{2qu}, \\ b(m, q, u) &= \sqrt{\frac{2u}{q}}, \\ z(m, q, u) &= 0. \end{aligned}$$

(b) *If $u > (1/2)q[\Delta(m)]^2$, then the limited liability constraint of the manager does not bind. The optimal managerial effort and contract are given by:*

$$\begin{aligned} e(m, q, u) &= q\Delta(m), \\ b(m, q, u) &= \Delta(m), \\ z(m, q, u) &= u - \frac{1}{2}q[\Delta(m)]^2. \end{aligned}$$

The proofs of the above proposition and many subsequent results are relegated to the Appendices. It is well-known that under risk neutrality and limited liability, for low values of manager's outside option u his participation constraint does not bind, i.e., he earns an *efficiency wage*. In the following section it is argued that in the equilibrium of the firm–manager market, the participation constraint of each manager binds, and hence the case of non-binding participation constraint is not considered in the above proposition. When the manager's limited liability constraint binds, the provision of incentives becomes costly for the owner, i.e., the moral hazard problem in effort choice becomes important. In this case, the manager earns a fixed salary equal to 0, the liability limit. The optimal effort and incentive pay are determined entirely by his outside option u and his type q since the bonus serves to compensate for the marginal cost of effort. These contracts are called the *second best* contracts. For high values of u, on the other hand, the limited liability constraint does not bind, and the effort incentive problem disappears. In other words, the *first best* effort level is implemented, and the entire value of managerial actions $\Delta(m)$ accrues to the manager. Note that the owner of the firm receives a fixed payment since

$$\begin{aligned} y(\theta_2, m) &\equiv \pi(\theta_2, m) - \Delta(m) - z(m, q, u) \\ &= \pi(\theta_1, m) - z(m, q, u) \equiv y(\theta_1, m). \end{aligned}$$

In this case the manager becomes the owner of the firm, and pays the owner the fixed price. Moreover, managerial effort and incentive pay are increasing (decreasing) in the firm's market power m if $\Delta'(m) > (<) 0$.

The incentive contracts are derived under the assumption that the firm is able to make a take-it-or-leave-it offer to its manager. Another type of optimal contract emerges when the manager has all the bargaining power. As the market equilibrium, analyzed in the following section, endogenizes the bargaining power of each firm and each manager, any particular type of incentive contract becomes irrelevant for our purpose.

3. Equilibrium when firms compete for managers

In this section I consider the case when the firms compete for managers in a common market for managers. To this end, I extend Sattinger's (1979) 'differential rents' model to an environment where each partnership is subject to moral hazard problems. Since only types, and not individual names matter, I assume that the allocation of managers to firms can be described by a matching function $q = \mu(m)$, or by its inverse $m = \nu(q)$. An allocation for the economy is thus an assignment rule μ, and the corresponding vectors of expected earnings $\boldsymbol{v}$ and $\boldsymbol{u}$ where $\nu(m) \in \boldsymbol{v}$ represents the payoff to each type m firm, and $u(q) \in \boldsymbol{u}$ represents the payoff to each type q manager. An equilibrium allocation is defined as follows.

Definition 1 *(equilibrium allocation).* An allocation $(\mu, \boldsymbol{v}, \boldsymbol{u})$ is an equilibrium allocation for the firm–manager market ξ if the following conditions are satisfied.

(a) Given $u(q)$ for $q \in Q$,

$$\mu(m) = \text{argmax}_q\, \phi(m,\ q,\ u(q)), \tag{M}$$

$$\nu(m) = \max_q \phi(m,\ q,\ u(q)),$$

for each $m \in M$.

(b) If $Q' = \mu(M')$ for $Q' \subseteq Q$ and $M' \subseteq M$, then Q' and M' have the same measure.

Treat $(u(q))_{q\in Q}$ as the Walrasian price vector for the managers. Part (a) of the above definition asserts that each type m firm chooses a manager in order to maximize its expected payoff, taking the price vector as given. Part (b) is a measure consistency requirement, the standard 'demand-supply equality' of a Walrasian equilibrium. Note that the set of Walrasian allocations of the firm–manager market coincides with the set of 'stable allocations'. An allocation is stable if no individual (individual rationality) or firm–manager pair (no pairwise blocking) can gain from some alternative feasible allocation.[6]

An equilibrium allocation $(\mu,\ \boldsymbol{v},\ \boldsymbol{u})$ is determined in the following steps.[7]

1 The marginal incomes $u'(q)$ of each type q manager and $\nu'(m)$ of each type m firm are respectively determined from the first-order necessary condition and the Envelope condition associated with the maximization problem (M) of each m.
2 Once the marginal income functions $u'(q)$ and $\nu'(m)$ are known, the income levels $u(q)$ and $\nu(m)$ are determined by solving the corresponding differential equations.
3 Finally, the second-order condition of the maximization problem (M) characterizes the optimal assignment function $\mu(m)$ or $\nu(q)$.

3.1. Determination of the equilibrium incomes

The Walrasian equilibrium allocation of this firm–manager market is determined as described in the previous subsection. While solving the maximization problem (M), the owner of a firm must guarantee her manager his outside option. The outside option u of a type q manager, who is matched with a type m firm, is the maximum payoff he can obtain by switching to other matches. I argue that in a Walrasian equilibrium, the income of a type q manager must be equal to his outside option, i.e., in every match (m, q) the participation constraint of the manager must bind. Suppose a manager of type q is offered $u(q)$ in an equilibrium allocation. Since there is a continuum of types, one can find an identical firm who would also offer $u(q)$ to the same manager, and hence $u(q)$ actually becomes the manager's outside option. Thus, any income offer strictly above the outside option cannot be part of a Walrasian equilibrium.[8] This is similar to the "no-surplus" condition of Ostroy (1984). This also implies that the outside option of each manager is endogenous.

Since the object of our interest is the Pareto frontier associated with each match (m, q), the following lemma states some important properties of the frontier.

Lemma 2. *Let $\phi(m,\ q,\ u(q))$ denote the Pareto frontier associated with a match (m, q) in a Walrasian equilibrium. Then,*

(a) $\phi_1(m,\ q,\ u(q)) > 0$, $\phi_2(m,\ q,\ u(q)) > 0$ and $\phi_3(m,\ q,\ u(q)) \le 0$;
(b) $\text{sign}[\phi_{21}(m,\ q,\ u(q))] = \text{sign}[\phi_{31}(m,\ q,\ u(q))] = \text{sign}[\Delta'(m)]$ if the second best contracts are implemented, and $\text{sign}[\phi_{21}(m,\ q,\ u(q))] = \text{sign}[\Delta'(m)]$ and $\phi_{31}(m, q, u(q)) = 0$ if the first best contracts are implemented.

Both greater market power and managerial talent increase the equilibrium expected payoff of a type m firm. The frontier associated with each match (m, q) is downward sloping in the sense that higher $u(q)$ implies lower payoff for the firm. The second part of the proposition will be used to characterize an equilibrium matching. Now, given Definition 1-(a), the first-order necessary condition of the maximization problem (M) of each type m firm implies that

$$u'(q) = -\left.\frac{\phi_2(m,\ q,\ u(q))}{\phi_3(m,\ q,\ u(q))}\right|_{m=\nu(q)}. \tag{1}$$

Since $\phi_2(m,\ q,\ u(q)) > 0$ and $\phi_3(m,\ q,\ u(q)) < 0$, the above expression is strictly positive. The left-hand-side of (1) is the marginal payoff of a type q manager who manages a type m firm, and the right-hand-side is the firm's marginal rate of substitution between managerial type and payoff. Applying the Envelope theorem to (M), one gets

$$\nu'(m) = \phi_1(m,\ q,\ u(q)) \quad \text{for}\ \ m = \nu(q), \tag{2}$$

which is also strictly positive. Therefore, the equilibrium expected incomes of the managers and firms are increasing in the corresponding types. This is because a more talented manager and a firm with higher market power have *absolute advantages* in any match irrespective of the type distributions. It is worth noting that any equilibrium allocation satisfies the 'equal treatment of equals' property, i.e., any two individuals of the same type obtain the same expected payoffs. This is a direct consequence of a downward sloping Pareto frontier corresponding to each partnership. Consider two managers, named A and B, of a given type q, and suppose that they obtain $u^A(q)$ and $u^B(q)$ such that $u^A(q) > u^B(q)$. If the current employer of A (who is of type m) employs B, then there is a net gain of $\phi(m, q, u^B(q)) - \phi(m, q, u^A(q)) > 0$ since $\phi_3(m, q, u(q)) < 0$. This extra gain can be divided between the employer of A and manager B contradicting the maximization behavior of the firm, and the current allocation will not be an equilibrium allocation. The above findings are summarized in the following proposition.

Proposition 1. *In a Walrasian allocation $(\mu,\ \boldsymbol{v},\ \boldsymbol{u})$, the payoffs of the firms and the managers are increasing in their corresponding types. Further, any Walrasian allocation satisfies the 'equal treatment of equals' property.*

The equilibrium income functions $u(q)$ and $\nu(m)$ are determined by solving the differential equations (1) and (2).[9]

3.2. The value of managerial actions and optimal assignment

The main objective of this subsection is to characterize the equilibrium matching function. First consider the following definition of a monotone matching.

[6] In 'assignment games' (e.g. Shapley & Shubik, 1971), *stability* has been used as a solution concept for a centralized market. It is immediate to show that the centralized solution coincides with the set of Walrasian allocations of a decentralized market.

[7] Kaneko (1982), and Legros, Newman, and Pejsachowicz (2010) prove the existence of an equilibrium allocation for this class of assignment models.

[8] For a manager, a slack participation constraint is a partial equilibrium phenomenon where only a single firm–manager pair is considered.

[9] To solve the differential equations, one needs to know the two corresponding initial conditions. Let $\underline{u}(q)$ and $\underline{\nu}(m)$ denote the *reservation payoffs* of each type q manager and each type m firm, respectively. The reservation payoffs, which are the payoffs of the unmatched individuals, $\underline{u}(q) = 0$ for all $q \in Q$, and $\underline{\nu}(m) = \pi(\theta_1,\ m)$. It is clear that the firms with the lowest m must consume its reservation payoff, i.e., $\underline{\nu}(m_{\min}) = \pi(\theta_1,\ m_{\min})$, and the least talented manager will earn $\underline{u}(q_{\min}) = 0$, since these are also their outside options. Therefore, $\underline{\nu}(m_{\min})$ and $\underline{u}(q_{\min})$ are respectively the initial conditions for the differential equations (1) and (2).

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Definition 2 *(assortative matching).* An equilibrium allocation $(\mu, \boldsymbol{\nu}, \boldsymbol{u})$ exhibits a positively (negatively) assortative matching if $\mu'(m) \geq (\leq) 0$, or equivalently $\nu'(q) \geq (\leq) 0$.

A positively assortative matching (PAM) implies that a manger with greater talent is lured into a firm with higher market power. I will determine under what conditions the equilibrium matching is assortative. The sign of $\nu'(q)$ is determined by the second-order condition associated with the maximization problem (M) of each type m firm, which is given by:

$$\phi_{22}(m,\ q,\ u(q)) - u''(q) \leq 0, \quad \text{for } m = \nu(q). \tag{3}$$

The above condition is equivalent to

$$[\phi_{21}(m,\ q,\ u(q)) + \phi_{31}(m,\ q,\ u(q))u'(q)]\nu'(q) \geq 0, \quad \text{for } m = \nu(q), \tag{4}$$

Lemma 2 implies that $\Delta'(m) > (<) 0$ is a sufficient condition for $\phi_{21} + \phi_{31}u'(q) > (<) 0$. Therefore,

Proposition 2. *If higher market power leads to increasing (decreasing) value of managerial actions, i.e.,* $\Delta'(m) > (<) 0$, *then an equilibrium allocation* $(\mu, \boldsymbol{\nu}, \boldsymbol{u})$ *exhibits a positively (negatively) assortative matching.*

I discuss the mechanism that induces a positively assortative matching, and the argument for negatively assortative matching (NAM) is similar. If greater market power leads to increasing value of managerial actions, i.e., $\Delta'(m) > 0$, then the firms with higher m gain more (at the margin) by employing more talented managers. In other words, when $\Delta(m)$ is increasing in m, more talented managers have *comparative advantages* over their less able counterparts in such firms. Therefore, more talented individuals manage firms with higher market power. A positively (negatively) assortative matching occurs due to a complementarity (substitutability) between market power and managerial talent. As far as a PAM is concerned, there are two aspects of such complementarity. First, there is a 'type-type' complementarity, i.e., $\phi_{21} > 0$, which says that market power and talent are complementary in producing surplus. Second, in addition to the above complementarity, there is a 'type-payoff' complementarity which is captured by the fact that $\phi_{31} > 0$. The idea behind this is the following. When matches are subject to imperfect transferability, the ease of transferring surplus from the firm to its manager becomes important. A PAM is also implied by the fact that for firms with greater market power it is easier to transfer surplus to the more talented managers, i.e., the corresponding Pareto frontier is less concave. Clearly, under the first best contract, the frontier is linear, and hence the type-payoff complementarity does not have any bite on the equilibrium matching, i.e., $\phi_{31} = 0$, and only the sign of ϕ_{21} determines the assortative matching.

The equilibrium matching function is determined as follows. Suppose a type m firm is assigned to a type q manager, and the matching is positively assortative. Then the measure consistency requirement in Definition 1-(b) implies that $F(q) = G(m)$ which implicitly defines $q = \mu(m)$. Note that $F(\cdot)$ is invertible since $f(\cdot) > 0$. Therefore,

$$\mu'(m) = \frac{g(m)}{f(\mu(m))} > 0.$$

On the other hand, if the equilibrium matching is negatively assortative, it must be the case that $F(q) = 1 - G(m)$, and hence

$$\mu'(m) = -\frac{g(m)}{f(\mu(m))} < 0.$$

Having determined the equilibrium matching rule μ or its inverse ν, it is now easy to determine which partnerships will implement the first best contracts. Since a type q manager's outside option in a Walrasian allocation is $u(q)$, and $m = \nu(q)$ for some m, this manager exerts second (first) best effort if

$$u(q) \leq (>) \frac{1}{2} q[\Delta(\nu(q))]^2$$
$$\Leftrightarrow \quad q \leq (>) u^{-1}\left(\frac{1}{2} q[\Delta(\nu(q))]^2\right) \equiv A(q).$$

Therefore,

Proposition 3. *There exists a unique* $q^* \in Q$, *defined by* $q^* = A(q^*)$, *such that any equilibrium partnership involving a managerial talent* $q \leq (>) q^*$ *implements the second (first) best efforts and incentive contracts.*

For managers with low level of talent, the limited liability constraints are more likely to bind, and hence such managers are more difficult to incentivize. Therefore, the partnerships involving less talented managers implement the second best contracts. On the other hand, partnerships involving highly talented managers are able to implement first best contracts. In such partnerships, owners of the firms receive a fixed payments, and their managers become the owners.

Finally, notice that the contract assigned to each partnership is a solution to the maximization problem (P). This is an *optimal* contract for a given partnership in an equilibrium allocation in the sense that there does not exist any other feasible contract for the match which would make both the firm and the manager strictly better off. If such a contract existed, then that would contradict the maximization behavior of the individual agents. On the other hand, the set of optimal contracts depends on the firm–manager assignment because associated with each arbitrary assignment there is a unique vector of optimal contracts. This calls for a stronger notion of Pareto optimality. Given an assignment and the corresponding set of optimal contracts, it is not possible to find another assignment rule in which all agents are weakly better off and some are strictly better off. Thus it is desirable to look for a matching rule, among the set of all possible assignments, which maximizes the aggregate surplus. In other words, an allocation is *Pareto optimal* if there does not exist any other allocation that makes everybody weakly better off and some strictly better off. Our equilibrium allocation has this property which is stated in the following proposition.

Proposition 4. *An equilibrium allocation* $(\mu, \boldsymbol{\nu}, \boldsymbol{u})$ *is Pareto optimal.*

To understand this point, consider an equilibrium with PAM. This occurs when $\Delta'(m) > 0$. The equilibrium surplus of a partnership (m, q) is given by $\Phi(m, q, u(q)) = \phi(m, q, u(q)) + u(q)$. Now suppose that a positively assortative equilibrium matching is not Pareto optimal. Then there must be two partnerships (m_1, q_2) and (m_2, q_1) in equilibrium with $m_1 < m_2$ and $q_1 < q_2$ such that

$$\Phi(m_1,\ q_2,\ u(q_2)) + \Phi(m_2,\ q_1,\ u(q_1)) > \Phi(m_1,\ q_1,\ u(q_1)) + \Phi(m_2,\ q_2,\ u(q_2)).$$

The above inequality is strict since under this assignment at least some agent is strictly better off. It follows from the above inequality that

$$\phi(m_1,\ q_2,\ u(q_2)) - \phi(m_1,\ q_1,\ u(q_1)) > \phi(m_2,\ q_2,\ u(q_2)) - \phi(m_2,\ q_1,\ u(q_1)) \Rightarrow \int_{q_1}^{q_2} [\phi(m_1,\ q,\ u(q)) - \phi(m_2,\ q,\ u(q))]dq > 0. \tag{5}$$

Condition (5) holds only if

$$\phi_{21}(m, q, u(q)) + \phi_{31}(m, q, u(q))u'(q) < 0,$$

a contradiction to the fact that $\Delta'(m) > 0$. Therefore, an equilibrium with positively assortative matching is the only Pareto optimal allocation. The arguments for the Pareto optimality of equilibrium allocations with negatively assortative matching can be constructed in a similar fashion. The above discussion also implies that a random matching would entail loss of efficiency if the equilibrium assignment must satisfy Condition (4).

3.3. Market power and the equilibrium managerial incentives

As we have discussed earlier that there has been an apparent consensus in the empirical literature that there exists a monotone relationship between market power and managerial incentives, although the theoretical literature arrived at a set of ambiguous predictions. The principal objective of this subsection is to provide a theoretical explanation for why equilibrium managerial incentives and effort are in general monotone with respect to market power or competition.

Consider the equilibrium bonus function which can be expressed as functions of the market power alone:

$$b(m) = b(m, \mu(m), u(\mu(m))).$$

I only consider the second best contracts here since incentives do not make much sense in a first best contract. Differentiating the above expression with respect to m one gets:[10]

$$\begin{aligned} b'(m) &= \frac{\partial b}{\partial m} + \frac{\partial b}{\partial q}\mu'(m) + \frac{\partial b}{\partial u}u'(q)\mu'(m) \\ &= H(m)\mu'(m). \end{aligned}$$

where $H(m) > 0$. Therefore,

$$\text{sign}[b'(m)] = \text{sign}[\mu'(m)].$$

Since $e = qb$, the equilibrium effort follows the same pattern with respect to m. It is easy to prove that

$$\text{sign}[e'(m)] = \text{sign}[\mu'(m)].$$

Therefore,

Proposition 5. *The firms with greater market power offer stronger (weaker) incentives, and induce higher (lower) managerial effort in equilibrium if greater market power leads to increasing (decreasing) value of managerial actions, i.e.,* $\Delta'(m) > (<) 0$.

The relationship between managerial incentives and market power is determined entirely by a *matching effect* which is basically the sign of $\mu'(m)$, which is in turn determined by the sign of $\Delta'(m)$. Thus, the model's prediction about the equilibrium incentives is unambiguous. If in a firm the gain from greater managerial effort is higher, such firms will lure more talented managers by offering stronger incentives. In a more general context, Wright (2003) identifies a similar effect, called the 'value-of-marginal-effort' effect which is key to signing the effect of firm type on managerial incentives.[11] Wright (2003) shows that less risk averse managers are lured into firms with greater marginal benefit of managerial effort, and such firms induce lower managerial slack and less *X*-inefficiency. Barros and Macho-Stadler (1998) analyzes a more particular context where a firm with larger initial market size benefits more at the margin from managerial effort, and employs a more talented manager following a positively assortative matching pattern and offers stronger incentives.

4. Sources of market power

Market power of a firm, i.e., its ability to price its product over and above the marginal cost may stem from various sources which may have differential implications for the equilibrium allocations, and in particular for managerial incentives. In what follows I consider three different sources of market power: market size, market-specific price cap regulation, and technological efficiency. In all cases, a higher value of m translates into greater price-cost margin, and the exercises boil down to analyzing the sign of $\Delta'(m)$ which implies assortative matching, and relationship between managerial incentives and market power.

4.1. Differences in market size

Consider a representative market m where higher m implies greater market size. As the firm-specific shock θ may be on demand or technology, two following scenarios will be considered. First, consider a scenario with stochastic demand and deterministic technology. In particular, let all firms face a linear inverse demand and a constant marginal cost of production, which are given by:

$$\begin{aligned} P(q; \theta, m) &= \theta + m - q, \\ c &= \bar{c}, \end{aligned}$$

where $\theta + m > \bar{c} \geq 0$ for $\theta \in \{\theta_1, \theta_2\}$. Thus, market size is determined by two parameters: m and θ. The higher the m, the greater is the market size, and hence the greater is the firm's market power. On the other hand, $\theta = \theta_2$ implies a greater market size in all markets. The principal task of a manager is thus to exert efforts in order to enhance firm's market size. The optimal product market profit is given by:

$$\pi(\theta, m) = \frac{(\theta + m - \bar{c})^2}{4}.$$

Therefore,

$$\Delta(m) = \frac{(\theta_2 - \theta_1)[2(m - \bar{c}) + \theta_1 + \theta_2]}{4} \quad \text{with} \quad \Delta'(m) = \frac{\theta_2 - \theta_1}{2} > 0.$$

The above implies that the equilibrium matching is positively assortative, and $b'(m), e'(m) > 0$.

Next, consider the case when each firm faces a deterministic demand and a constant stochastic marginal cost of production, i.e.,

$$\begin{aligned} P(q; m) &= m - q, \\ c(\theta) &= \bar{c} - \theta, \end{aligned}$$

where $m > \bar{c} - \theta$ for $\theta \in \{\theta_1, \theta_2\}$. In this case, the task of a manager is to make firm's technology more efficient by exerting R&D effort. A particular scenario would be $\theta_1 = 0$ and $0 < \theta_2 \leq \bar{c}$. This implies that a self-managed firm always stays inefficient with a marginal cost $c = \bar{c}$. Thus, managerial effort helps reducing the marginal cost, a case similar to Schmidt (1997). It is immediate to see that this case is equivalent to the previous one, and hence has the same implications for the equilibrium allocations. Thus, it follows from Propositions 2 and 5 that

Proposition 6. *Under linear market demands when higher m implies greater market size, in a Walrasian equilibrium the matching is positively assortative, and firms with greater market power induce higher*

[10] See Appendix for details.

[11] Wright abstracts from the fundamentals of the product markets where the firms sell their goods, and see the effect of competition among firms in the market for risk averse managers who are heterogenous with respect to attitude towards risk.

managerial effort by offering more high-powered incentives irrespective of the fact that the firm-specific shock is on demand or on technology.

The equivalence between the above two cases is a mere coincidence since all firms face linear demands in the respective product markets. Even under more general demands and costs, the result of the above proposition holds good. What is important is that when higher values of m enhance market size, irrespective of a demand or technological shock, higher m implies a greater price-cost margin, and hence, firms with greater market power have incentives to offer stronger managerial incentives since greater m implies higher values of managerial actions.

4.2. Differences in market-specific regulation

Often market power stems from market-specific regulatory regimes. Following Cabral and Riordan (1989), I consider a simple example to show that in a market with regulated price when lower m implies tighter price cap, the implications of changes in market power for the equilibrium allocations may be quite different depending on the nature of the firm-specific shock. Consider the representative market where m represents the price cap which is below the optimal monopoly price. Clearly, each firm will set its price at m, the maximum permissible price.

First, consider the case where each firm m faces a linear stochastic demand at the market price P which given by $D(P;\theta)=\theta-P$, whereas the firm's constant marginal cost of production is given by $c=\bar{c}<\theta$ for $\theta\in\{\theta_1, \theta_2\}$. Thus, each firm sets a quantity equal to $\theta-m$ at state θ. A tighter price cap (lower m) implies a lower price-cost margin, and hence a lower market power. A manager's task is thus to enhance the market size by exerting effort. The profit in market m is given by:

$$\pi(\theta, m)=(m-\bar{c})(\theta-m),$$

which implies $\Delta'(m)=\theta_2-\theta_1>0$, and hence the equilibrium matching is positively assortative, and $b'(m), e'(m)>0$.

Next, consider a deterministic demand $D(m)=\alpha-P$ at market price P but a stochastic marginal cost $c=\bar{c}-\theta\in[0, \alpha)$ for $\theta\in\{\theta_1, \theta_2\}$. The equilibrium quantity at market m is given by $\alpha-m$. The manager in firm m is offered incentives to make the technology more efficient. In this case we have

$$\pi(\theta, m)=(m-\bar{c}+\theta)(\alpha-m),$$

which implies $\Delta'(m)=-(\theta_2-\theta_1)<0$, and hence the equilibrium matching is negatively assortative, and $b'(m), e'(m)<0$. It thus follows from Propositions 2 and 5 that

Proposition 7. *Under market-specific price cap regulation when lower m implies tighter price cap, in a Walrasian equilibrium*

(a) *the matching is positively assortative, and firms with greater market power induce higher managerial effort by offering stronger incentives if the idiosyncratic shock is demand-specific;*
(b) *the matching is negatively assortative, and firms with greater market power induce lower managerial effort by offering weaker incentives if the idiosyncratic shock is technology-specific.*

When the idiosyncratic shock is on market demand, the intuition behind a PAM and that firms with greater market power provide stronger incentives is not hard to understand. At any given price P, an increase in θ from θ_1 to θ_2 implies an increase in quantity produced by $(\theta_2-P)-(\theta_1-P)=\theta_2-\theta_1$ which is constant with respect to P. In particular, the increase in quantity is the same under both prices m and m'. On the other hand, since the constant marginal cost is not state-dependent, under higher m the profit margin $m-\bar{c}$ is higher which applies to the same increase in quantity yielding a higher value of managerial actions. Therefore, more talented managers are lured into firms with greater market power, and they are offered stronger incentives which elicit higher managerial efforts. When the idiosyncratic shock is on technology, the above results are reversed. Under any two market prices m and m' with $m>m'$ cost saving per unit is the same which is equal to $(\bar{c}-\theta_1)-(\bar{c}-\theta_2)=\theta_2-\theta_1$ which applies to a higher quantity under a lower price cap m' since the market demand is downward sloping. This yields a lower value of managerial actions in market m, and hence in the equilibrium allocation there is negative sorting, and weaker incentives are associated with greater market power.

4.3. Differences in technology

Apart from several market fundamentals such as market size and regulation, differences in market power may also stem from differences in technology. For example, the constant marginal cost of production $c(m)$ of firm m, among other things depends on m with $c'(m)<0$. In this case, greater m implies higher price-cost margin, and hence higher market power. In order to analyze the implications of varying market power for the Walrasian allocations consider a simple example with linear demand and constant marginal cost. As before, I consider two different scenarios with the idiosyncratic shock being either on demand or on technology. First, consider the inverse demand of the form $P(q;\theta)=\alpha+\theta-q$ with $\alpha>0$, and the constant marginal cost is given by $c(m)=\bar{c}-m<\alpha+\theta$ for $\theta\in\{\theta_1, \theta_2\}$. The product market profit of a type m firm at state θ is given by:

$$\pi(\theta, m)=\frac{[(\alpha+\theta)-(\bar{c}-m)]^2}{4}.$$

Therefore,

$$\Delta(m)=\frac{(\theta_2-\theta_1)[2(\alpha+m-\bar{c})+\theta_1+\theta_2]}{4} \quad \text{with} \quad \Delta'(m)=\frac{\theta_2-\theta_1}{2}>0.$$

The above implies that the equilibrium matching is positively assortative, and $b'(m), e'(m)>0$.

Next, consider a deterministic demand $P(q)=\alpha-q$ but stochastic constant marginal cost $c(\theta, m)=\bar{c}-m-\theta\in[0, a)$ for $\theta\in\{\theta_1, \theta_2\}$. In this case, the manager of a firm with market power m exerts effort to reduce cost although he faces a more efficient technology than his counterpart in a type m' firm where $m>m'$. This example yields a product market profit $\pi(\theta, m)$ which is exactly the same as in the previous case, and hence the equilibrium allocation exhibits PAM, and $b'(m), e'(m)>0$. Therefore, Propositions 2 and 5 together imply that

Proposition 8. *Under linear market demands when higher m implies more efficient technology, in a Walrasian equilibrium the matching is positively assortative, and firms with greater market power induce higher managerial effort by offering more high-powered incentives irrespective of the fact that the firm-specific shock is on demand or on technology.*

The equivalence between the two cases emerge because of the linear demand, but the results would continue to hold under more general specifications of demand and cost functions. The intuition is similar to that of Proposition 6.

5. Discussions

5.1. Debt versus equity contracts

Under binding limited liability constraint of a manager, it follows from Innes (1990) that the optimal managerial contract is a debt contract, i.e., in the Walrasian allocation in a partnership (m, q) the manager receives $b(m, q, u(q))$ if $\theta = \theta_2$, and nothing if $\theta = \theta_1$. It is also well-known that under binary realizations of shock, debt and equity contracts are indistinguishable. Instead of the contracts described in Section 2.2, consider a profit-sharing or equity-based contract where the manager in firm m receives $\gamma\pi(\theta, m)$ with $0 \le \gamma \le 1$ at state $\theta \in \{\theta_1, \theta_2\}$. The parameter γ represents the manager's pay-to-performance sensitivity, which is an appropriate measure of incentives for managerial actions whose dollar impact is the same regardless of m, the firm characteristic (see Jensen & Murphy, 1990; Murphy, 1999). Note that, in light of our model, one has $b = \gamma\Delta(m)$, which is the value of equity at stake of the manager. It is easy to show that such equity-based contracts implement the same effort levels as does the contracts (z, b) in a given partnership.

Apart from the pay-to-performance sensitivity, the value of equity at stake as a measure of managerial incentives has been used extensively in the literature (e.g. Baker & Hall, 2004). Since in an assignment model, as in the current one, equilibrium managerial incentives depend on the firm characteristics, Edmans et al. (2009) and Frydman and Saks (2010) argue that value of equity at stake, $\gamma\Delta(m)$ should be an appropriate measure of incentives for managerial actions as opposed to pay-to-performance sensitivity, γ. Clearly, none of the above results would change if one interpret the managerial bonus b as the value of equity. Therefore, it follows from Proposition 5 that if $\Delta'(m) > (<) 0$, then value of equity is increasing in m. Since $\Delta'(m) > (<) 0$ implies a positively (negatively) assortative matching, i.e., more talented individuals manage firms with higher (lower) market power, in a Walrasian equilibrium, higher equity/incentive pay is associated with greater talent, which conforms to the recent empirical literature (e.g. Edmans et al., 2009; Frydman & Saks, 2010) on managerial incentives.

5.2. Self-managed versus owner-manager firms

In the present model I have made the assumption that managerial services are essential to a firm's production process, i.e., in all firms there exists separation of ownership. In Section 2, I have also discussed how such ownership structure may be justified. Thus, in a self-managed firm the owner does not have the ability to enhance firm's performance, i.e., increase the level of profit from $\pi(\theta_1, m)$ to $\pi(\theta_2, m)$. The current model may be extended to include the possibility of a productive self-managed firm in a very simple way. Consider a situation where both the owner and the manager have to exert efforts, which are denoted by a and e, respectively. The probability of high profit $\pi(\theta_2, m)$ is given by $p(a, e)$ with $p(a, 0) > 0$.[12] Thus, the owner of a self-managed firm is able to enhance firm's profit by exerting effort. Under certain regularity conditions on the probability of success function $p(\cdot, \cdot)$, and assuming that the incentive contracts are feasible in the sense that each owner-manager firm generates a greater expected surplus than a self-managed firm, many of the above results will hold good. I have not considered this possibility in the present paper since a self-managed firm is not subject to incentive problems, and the main focus is on the effect of varying market power on managerial incentive pay.

6. Concluding remarks

The present paper purses two objectives: (a) propose a unified framework which is able to simultaneously determine the level as well as the incentive structure the executive compensation packages, and (b) derive predictions regarding the effects of firms' market power on managerial incentives. A model of firm–manager assignment, where each match is subject to effort incentive problems, establishes a one-to-one relationship between market power and value of managerial actions. Firms that enjoy greater value of managerial actions lure managers who are relatively easier to incentivize because they are more talented, induce higher effort, and offer more high-powered managerial incentives. As opposed to many existing models analyzing the effect of market power/competition on managerial incentives, the present model makes unambiguous predictions about the equilibrium relationship between market power and incentives: greater (lower) market power implies stronger incentives if firms with higher market power employ 'better' managers following a positively (negatively) assortative matching pattern.

Differences in market power or level of competition that differentially affect the profitability of the firms, and hence the executive compensation packages, may stem from differences in several firm-specific exogenous factors such as geographic location (e.g. Hubbard & Palia, 1995), regulation (e.g. Palia, 2000), exchange rate fluctuation (e.g. Cuñat & Guadalupe, 2005), degree of product substitutability (e.g. Beiner et al., 2011). Depending on the differences in the sources of market power, recent empirical literature has predicted either stronger or weaker incentives following a change in market power or level of competition. For example, Hubbard and Palia (1995), Palia (2000), and Cuñat and Guadalupe (2005) among others predict that stronger managerial incentives are associated with more intense product market competition. In particular, comparing firms in the regulated energy sector with those in the manufacturing sector, Palia (2000) finds that the market for executives sorts managers with lower-quality education into more regulated business environment. Beiner et al. (2011) find a negative relationship between competition and managerial incentives. The present paper provides explanation for monotone relationship between competition and managerial incentives which is consistent with the aforementioned empirical findings. The results in the Section 4 assert that one has to take into account various possible sources of market power in order to see whether firms with higher market power benefit more from managerial actions, and hence conclude about any definitive relationship between competition and incentives. As discussed earlier, the endogenous firm–manager matching plays an important role in the determination of such relationship.

Mine is a stylized model of firm–manager matching and incentive contracts, which employs a number of simplifying assumptions. At this juncture, some limitations of the current model must be recognized. The analysis assumes away strategic interactions among several firms in a common product market. More than one firms could have been assumed to compete in differentiated products in a Cournot or Bertrand fashion where the degree of product differentiation would represent market power for each firm within the same industry. In this case the gross profit that a particular firm earns from the respective product market would also depend on the realizations of the cost parameters of its rivals, which are determined by the abilities of the managers employed by them. Thus, the hiring decision of one firm would

[12] On particular functional form would be $p(a, e) = (1 - \delta)a + \delta e$ where $\delta \in [0, 1]$. Thus, $\delta = 1$ corresponds to an owner-manager firm as in Section 2, and $\delta = 0$ implies a self-managed firm.

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inflict an externality on its rivals within the same product market. The theory of two-sided matching markets has almost been silent in this regard.[13] Second, a more ambitious model would consider many-to-one matching among the firms and managers where each firm is allowed to hire more than one manager, or one manager may moonlight in other firms. The first case is qualitatively equivalent to the model presented in the current paper if managerial abilities are not correlated. The contracts I derive here may not be optimal if there was some degree of correlation among the managerial types, and this would call for analyzing other complex contracts such as relative performance evaluation, tournaments, etc. The second case gives rise to a situation where a particular firm is unable to limit the number of relationships one manager can enter into. This induces a problem where contracts are non-exclusive, and the second-best contracts described in Subsection 2.2 may not be implementable.[14] Extensions of the current model that include the aforesaid features of firm–manager assignment will be an interesting future research agenda.

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Appendix A. Proof of Lemma 1

In an arbitrary partnership (m, q), a type m firm solves the following maximization problem.

$$\max_{\{z,b,e\}} \ e\pi(\theta_2, m) + (1-e)\pi(\theta_1, m) - z - eb$$
$$= e[\Delta(m) - b] + \pi(\theta_1, m) - z, \quad (\mathrm{M}_1)$$

$$\text{subject to} \quad qb = e, \quad (\mathrm{IC})$$

$$z + b \geq 0, \quad (\mathrm{LL}_2)$$

$$z \geq 0, \quad (\mathrm{LL}_1)$$

$$z + eb - \frac{e^2}{q} \geq u. \quad (\mathrm{PC})$$

From (IC) one clearly has that $b \geq 0$, which together with (LL_1) implies that (LL_2) always holds good, and hence can be ignored. I only consider the case when (PC) binds at the optimum. Thus, substituting for $e = qb$, the above maximization problem boils down to:

$$\max_{\{f,b\}} \ qb[\Delta(m) - b] + \pi(\theta_1, m) - z, \quad (\mathrm{M}_{1'})$$

$$\text{subject to} \quad \frac{1}{2}qb^2 + z \geq u, \quad (\mathrm{PC}')$$

$$z \geq 0. \quad (\mathrm{LL}_2)$$

The Lagrange function is given by:

$$\mathcal{L} = qb[\Delta(m) - b] + \pi(\theta_1, m) - z + \lambda_1\left[\frac{1}{2}qb^2 + z - u\right] + \lambda_2 z.$$

The Karush–Kuhn—Tucker conditions are given by:

$$\Delta(m) - 2b + \lambda_1 b = 0, \quad (\mathrm{FOC}_1)$$

$$\lambda_1 + \lambda_2 = 1, \quad (\mathrm{FOC}_2)$$

$$\lambda_1\left[\frac{1}{2}qb^2 + z - u\right] = 0, \quad (\mathrm{FOC}_3)$$

$$\lambda_2 z = 0, \quad (\mathrm{FOC}_4)$$

$$\lambda_1, \lambda_2 \geq 0. \quad (\mathrm{FOC}_5)$$

First consider the case when the limited liability constraint (LL_2) binds at the optimum, i.e., $z = 0$. Then from binding (PC), one has $qb^2 = 2u$, which defines the optimal bonus. Then, from (IC) it follows that $e^2 = 2qu$. Since both $\lambda_1, \lambda_2 \geq 0$, from ($\mathrm{FOC}_1$) and ($\mathrm{FOC}_2$) it follows that

$$0 \leq \lambda_1 \leq 1 \quad \Leftrightarrow \quad \frac{\Delta(m)}{2} \leq b \leq \Delta(m). \qquad (\mathrm{A}.1)$$

Further, from the last inequality it follows that the candidate solutions are indeed optimum only if

$$u \leq \frac{1}{2}q[\Delta(m)]^2.$$

Next, consider the case when (LL_2) does not bind at the optimum. In this case, $\lambda_2 = 0$, and (FOC_2) implies that $\lambda_1 = 1$. Then from (FOC_1) it follows that $b = \Delta(m)$. Then (IC) implies that $e = q\Delta(m)$. The optimal base salary z is determined from the binding (PC′), which is given by:

$$z = u - \frac{1}{2}q[\Delta(m)]^2.$$

Since $z > 0$ from the above equation it follows that the candidate solutions are indeed optimum only if

$$u > \frac{1}{2}q[\Delta(m)]^2.$$

This completes the proof of the lemma. ■

Appendix B. Proof of Lemma 2

The Pareto frontier is given by:

$$\phi(m, q, u) = qb(m, q, u)[\Delta(m) - b(m, q, u)]$$
$$+ \pi(\theta_1, m) - z(m, q, u).$$

By Envelope theorem it follows that

$$\begin{aligned}
\phi_1(m, q, u) &= \frac{\partial \mathcal{L}}{\partial m} = qb(m, q, u)\Delta'(m) + \frac{\partial \pi(\theta_1, m)}{\partial m} \\
&= e(m, q, u)\frac{\partial \pi(\theta_2, m)}{\partial m} + [1 - e(m, q, u)]\frac{\partial \pi(\theta_1, m)}{\partial m} > 0, \\
\phi_2(m, q, u) &= \frac{\partial \mathcal{L}}{\partial q} = b(m, q, u)[\Delta(m) - b(m, q, u)] + \frac{\lambda_1 b^2(m, q, u)}{2} \\
&= \frac{b(m, q, u)\Delta(m)}{2} > 0, \\
\phi_3(m, q, u) &= \frac{\partial \mathcal{L}}{\partial u} = -\lambda_1 = -\frac{2b(m, q, u) - \Delta(m)}{b(m, q, u)} \leq 0.
\end{aligned}$$

[13] Li (1993), and Sasaki and Toda (1996) are among the few attempts made in this context.

[14] See Kahn and Mookherjee (1998), and Parlour and Rajan (2001) for the analyses of non-exclusive contracts.

Now consider first the second best contracts under which $q[b(m, q, u)]^2 = 2u$, which implies

$$\frac{\partial b(m, q, u)}{\partial m} = 0.$$

Therefore,

$$\phi_{21}(m, q, u) = \frac{b(m, q, u)\Delta'(m)}{2},$$

$$\phi_{31}(m, q, u) = \frac{\Delta'(m)}{b(m, q, u)}.$$

The above two equations imply that $\text{sign}[\phi_{21}] = \text{sign}[\phi_{31}] = \text{sign}[\Delta'(m)]$.

Next, consider the first best contracts in which $b(m, q, u) = \Delta(m)$. Therefore, $\phi_2 = [\Delta(m)]^2/2$ and $\phi_3 = -1$, and hence

$$\phi_{21}(m, q, u) = \Delta(m)\Delta'(m) \quad \Rightarrow \quad \text{sign}[\phi_{21}] = \text{sign}[\Delta'(m)],$$

$$\phi_{31}(m, q, u) = 0.$$

This completes the proof of the lemma. ■

Appendix C. Proof of Proposition 2

The second-order condition of the maximization problem (M) is given by:

$$\begin{aligned}\phi_{22}(m, q, u(q)) &+ \phi_{23}(m, q, u(q)) + [\phi_{32}(m, q, u(q)) \\ &+ \phi_{33}(m, q, u(q))u'(q)]u'(q) \\ &+ \phi_3(m, q, u(q))u''(q) \leq 0, \quad \text{for} \quad m = \nu(q).\end{aligned} \tag{C.1}$$

Differentiating (1) with respect to m at $q = q(m)$, one gets

$$\begin{aligned}u''(q) = &-\frac{1}{\phi_3^2}[\phi_3(\phi_{21}\nu'(q) + \phi_{22} + \phi_{23}u'(q)) \\ &- \phi_2(\phi_{31}\nu'(q) + \phi_{32} + \phi_{33}u'(q)].\end{aligned}$$

Now substitute for $u'(q)$ and $u''(q)$ in (4) to get

$$[\phi_{21}(m, q, u(q)) + \phi_{31}(m, q, u(q))u'(q)]\nu'(q) \geq 0. \tag{C.2}$$

Now consider the case when the second best contracts are implemented. From Lemma 2 it follows that if $\Delta'(m) > (<) 0$ then both $\phi_{21} > (<) 0$ and $\phi_{31} > (<) 0$. Since $u'(q) > 0$, condition (C.2) holds only if $\nu'(q) \geq (\leq) 0$. Finally, consider the case when the first best contracts are implemented. Then $\phi_{31} = 0$. If $\Delta'(m) > (<) 0$ then $\phi_{21} > (<) 0$ from Lemma 2, and hence condition (C.2) holds only if $\nu'(q) \geq (\leq) 0$. Therefore, both under the first and second best contracts, $\Delta'(m) > (<) 0$ implies that the equilibrium matching is positively (negatively) assortative. ■

Appendix D. Proof of Proposition 3

The second (first) best contracts are implemented in a match where the manager type is q only if

$$q \leq (>) u^{-1}\left(\frac{1}{2}q[\Delta(\nu(q))]^2\right) \equiv A(q).$$

Note that

$$A'(q) = \frac{\Delta(\nu(q))}{2u'(q)}[\Delta(\nu(q)) + \Delta'(\nu(q))\nu'(q)] > 0$$

since $\Delta'(\nu(q))$ and $\nu'(q)$ are of the same sign in equilibrium. Note that $A(q)$ is a continuous and strictly increasing mapping on a compact interval $Q = [q_{min}, q_{max}]$. Also, if some partnerships implements the second best contracts and some, the first best contracts, it must be the case that at least one partnership involves q_{min} and at least another partnership involves q_{max}. This implies

$$q_{\min} \leq A(q_{\min}) < A(q_{\max}) < q_{\max}.$$

Therefore by the Intermediate Value Theorem, $A(q)$ has a unique fixed point q^*. This completes the proof of the proposition. ■

Appendix E. Proof of Proposition 5

First consider the optimal bonus under the second best contracts which is defined by $qb^2 = 2u$. Then,

$$\frac{\partial b}{\partial m} = 0,$$

$$\frac{\partial b}{\partial q} = -\frac{b}{2q},$$

$$\frac{\partial b}{\partial u} = \frac{1}{qb}.$$

The equilibrium bonus function with respect to m can be written as

$$b(m) = b(m, \mu(m), u(\mu(m))).$$

Differentiating the above with respect to m one gets

$$\begin{aligned}b'(m) &= \left[\frac{\partial b}{\partial q} + u'(q)\frac{\partial b}{\partial u}\right]\mu'(m) = \left[\frac{\partial b}{\partial q} - \frac{\phi_2}{\phi_3}\frac{\partial b}{\partial u}\right]\mu'(m) \\ &= \left[-\frac{b}{2q} + \frac{\Delta(m)b^2}{2[2b - \Delta(m)]}\frac{1}{qb}\right]\mu'(m) \\ &= \frac{b[\Delta(m) - b]}{q[2b - \Delta(m)]}\mu'(m) \equiv H(m)\mu'(m).\end{aligned}$$

Since $\Delta(m)/2 \leq b \leq \Delta(m)$, $H(m) \geq 0$ for all m, and hence $\text{sign}[b'(m)] = \text{sign}[\mu'(m)] = \text{sign}[\Delta'(m)]$.

Next, consider the optimal effort under the second best contracts which is defined by $e^2 = 2qu$. Then,

$$\frac{\partial e}{\partial m} = 0,$$

$$\frac{\partial e}{\partial q} = \frac{u}{e} = \frac{b}{2} > 0,$$

$$\frac{\partial e}{\partial u} = \frac{q}{e} = \frac{1}{b} > 0,$$

since $e = qb$. The equilibrium effort function with respect to m can be written as

$$e(m) = e(m, \mu(m), u(\mu(m))).$$

Differentiating the above with respect to m one gets

$$e'(m) = \left[\frac{\partial e}{\partial q} + u'(q)\frac{\partial e}{\partial u}\right]\mu'(m) \equiv K(m)\mu'(m).$$

Since $\partial e/\partial q$, $\partial e/\partial u$ and $u'(q)$ are all strictly positive, $K(m) > 0$, and hence $\text{sign}[e'(m)] = \text{sign}[\mu'(m)] = \text{sign}[\Delta'(m)]$. This completes the proof of the proposition. ■

References

Ackerberg, D., & Botticini, M. (2002). Endogenous matching and the empirical determinants of contract form. *Journal of Political Economy*, *110*, 564–591.

Aggarwal, R., & Samwick, A. (1999). Executive compensation, strategic competition, and relative performance evaluation: theory and evidence. *The Journal of Finance*, *54*, 1999–2043.

Baker, G., & Hall, B. (2004). CEO incentives and firm size. *Journal of Labor Economics*, *22*, 767–798.

Baranchuk, N., MacDonald, G., & Yang, J. (2011). The economics of super managers. *The Review of Financial Studies*, *24*, 3321–3368.

Barros, F., & Macho-Stadler, I. (1998). Competition for managers and product market efficiency. *Journal of Economics & Management Strategy*, *7*, 89–103.

Beiner, S., Schmid, M., & Wanzenried, G. (2011). Product market competition, managerial incentives, and firm valuation. *European Financial Management*, *17*, 331–366.

Cabral, L., & Riordan, M. (1989). Incentives for cost reduction under price cap regulation. *Journal of Regulatory Economics*, *1*, 93–102.

Chiappori, P.-A., & Salanié, B. (2003). Testing Contract Theory: A Survey of Some Recent Work. In M. Dewatripont, L. P. Hansen, & S. Turnovsky (Eds.), *Advances in Economics and Econometrics: Theory and Applications, Eighth World Congress, Volume I*. Cambridge University Press, pp. 115-149, Econometric Society Monographs.

Cuñat, V., & Guadalupe, M. (2005). How does product market competition shape incentive contracts? *Journal of the European Economic Association*, *3*, 1058–1082.

Edmans, A., Gabaix, X., & Landier, A. (2009). A multiplicative model of optimal CEO incentives in market equilibrium. *The Review of Financial Studies*, *22*, 4881–4917.

Frydman, C., & Saks, R. (2010). Executive compensation: A new view from a long-term perspective, 1935–2005. *The Review of Financial Studies*, *23*, 2099–2138.

Hart, O. (1983). Market mechanism as an incentive scheme. *Bell Journal of Economics*, *14*, 366–382.

Hermalin, B. (1992). The effects of competition on executive behavior. *The RAND Journal of Economics*, *14*, 350–365.

Hubbard, R. G., & Palia, D. (1995). Executive pay and performance: evidence from the U.S. banking industry. *Journal of Financial Economics*, *39*, 105–130.

Innes, R. (1990). Limited liability and incentive contracting with ex-ante action choices. *Journal of Economic Theory*, *52*, 45–67.

Jensen, M., & Murphy, K. (1990). Performance pay and top-management incentives. *Journal of Political Economy*, *98*, 225–264.

Kahn, C., & Mookherjee, D. (1998). Competition and incentives with nonexclusive contracts. *The RAND Journal of Economics*, *29*, 443–465.

Kaneko, M. (1982). The central assignment game and the assignment markets. *Journal of Mathematical Economics*, *10*, 205–232.

Karuna, C. (2007). Industry product market competition and managerial incentives. *Journal of Accounting and Economics*, *43*, 275–297.

Kole, S., & Lehn, K. (1997). Deregulation, the evolution of corporate governance structure, and survival. *The American Economic Review*, *87*, 421–425.

Legros, P., Newman, A., & Pejsachowicz, L. (2010). *Matching and welfare in large markets – With an application to monitoring in teams*. Mimeo: Université Libre de Bruxelles and Boston University.

Leibenstein, H. (1966). Allocative efficiency vs. 'X-efficiency'. *The American Economic Review*, *56*, 392–415.

Li, S. (1993). *Competitive matching equilibria and multiple principal–agent models*. mimeo: University of Minnesota.

Murphy, K. (1999). Executive compensation. In O. Ashenfelter, & D. Card (Eds.), *Handbook of labor economics. Vol. 3B* (pp. 2485–2518). Amsterdam and New York: North Holland.

Nickell, S. (1996). Competition and corporate performance. *The Journal of Political Economy*, *104*, 724–746.

Novshek, W. (1980). Cournot equilibrium with free entry. *The Review of Economic Studies*, *47*, 473–486.

Ostroy, J. (1984). A reformulation of the marginal productivity theory of distribution. *Econometrica*, *52*, 599–630.

Palia, D. (2000). The impact of regulation on CEO labor markets. *The RAND Journal of Economics*, *31*, 165–179.

Parlour, C., & Rajan, U. (2001). Competition in loan contracts. *The American Economic Review*, *91*, 1311–1328.

Raith, M. (2003). Competition, risk, and managerial incentives. *The American Economic Review*, *93*, 1425–1436.

Sasaki, H., & Toda, M. (1996). Two-sided matching problems with externalities. *Journal of Economic Theory*, *70*, 93–108.

Sattinger, M. (1979). Differential rents and the distribution of earnings. *Oxford Economic Papers*, *31*, 60–71.

Scharfstein, D. (1988). Product-market competition and managerial slack. *The RAND Journal of Economics*, *19*, 147–155.

Schmidt, K. (1997). Managerial incentives and product market competition. *The Review of Economic Studies*, *64*, 191–213.

Shapley, L., & Shubik, M. (1971). The assignment game I: The core. *International Journal of Game Theory*, *1*, 111–130.

Wright, D. (2003). Managerial incentives and firm efficiency in the presence of competition for managers. *International Journal of Industrial Organization*, *21*, 419–437.

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