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Bidding for teams[☆]

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ABSTRACT

We develop a simple competing job auction model to study wages and employment within teams. If synergies favor larger teams, the basic competing job auction model predicts that workers are generally paid a wage less than their marginal product of labor and that there is too much entry of firms. We then extend the model to allow for workplace competition. In this case, the firms can also compete by a commitment to job amenities and a minimum scale of operation. We then find that wages are always equal to the marginal product of labor and entry of firms is efficient.

1. Introduction

Teams play a central role in the internal organization of firms.[1] Yet, existing models used to study the labor market ignore this internal organization of firms. For example, in the canonical Diamond–Mortensen–Pissarides model, a job is simply a match between a worker and a firm, i.e. there are constant returns in production. This paper departs from this convention, by studying the formation of production teams in which the output of one team member depends on the presence of other team members.

The goal of this paper is to study the equilibrium assignment of workers to teams using a simple competing job auction model (McAfee, 1993; Shimer, 1999). We assume that a firm can employ either one or two workers. We also allow for team synergies such that larger teams may have a higher average product than smaller teams. For example, if the task of the team is to move a large item, we might assume that the team cannot complete the task if there is only one worker in the team, but that the team can complete the task if there are two workers in the team. In this example, each worker's marginal product is equal the value of the entire task, which exceeds the team members' average product.

A key restriction on the pricing of teams by auctions is that the workers must be paid a wage below their marginal product whenever the worker's marginal product exceeds the average product of the team.[2] This contrasts to the standard case with constant or global decreasing returns to scale, when workers can be paid their marginal product. However, paying workers their marginal product is not feasible when there are local increasing returns to scale, because the marginal product of labor will exceed the average product of labor. Therefore, in the example of moving a large item, the firm pays the worker a wage equal to half the value of the task when there are two workers and a wage of zero otherwise.

If synergies favor larger teams, wages are less than the marginal product of labor and the simple competing job auction model predicts that the expected team size is generally too small from a social perspective. In effect, we have a reverse lemons problem. If the team synergies are such that two workers in a team produce more than twice as much output as a single worker, the competing job auction market will break down because it will attract too many firms. In the extreme, if the costs of firm entry are very small, then workers will find it impossible to find employment in a productive team, because there are too many employers and thus too little possibility of locating a team with a complementary team co-worker. Therefore, since firms do not internalize the costs

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[1] Over the past three decades, organizational change within firms has lead to a proliferation of modern human resource management practices, such as self-managed teams and performance pay (e.g. Bloom and Reenen, 2011).

[2] This restriction conforms to the standard assumption that total match wages must not exceed total match output.

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of these lost opportunities, a tax on firm entry is needed to reduce firm entry.[3]

We then consider a broader model of job auctions, which we call a competing workplace auction model. In this model, teams compete against each other for applicants by posting workplace amenities (e.g. Julien et al., 2000).[4] The resulting competition among teams leads to firms internalizing the entry externality and the resulting allocation coincides with the planner's solution. Yet, in the presence of increasing returns, the posted amenity is not zero. This contrasts to the existing literature studying competing auctions (Albrecht et al., 2012; 2014; Peters and Severinov, 1997) which finds a reserve price of zero implements the constrained efficient allocation. However, in these models, typically only two agents trade with each other, which is akin to assuming constant returns. Here we show that deviating from the assumption of constant returns breaks the zero reserve price result.[5]

Our competing job auction model includes as a special case, the standard model of pairwise matching, which is analyzed in Shimer (1999). In the special case of one worker firms, the marginal value of the first worker is the output of the firm and the marginal value of the second worker is zero. Therefore, under simple job auctions, the nth applicant to a firm is always paid his marginal project and the equilibrium is efficient. Therefore, if firms seek to hire a single worker (or, more generally, if the marginal product of each additional worker is always declining), the simple competing job auction model and the competing workplace auction model are equivalent.

Some previous work has investigated directed search models with multi-worker firms.[6] The paper closest to ours is Tan (2012) who studies a directed search model in which firms first invest into an optimal size and then seek to hire workers. If the firm fails to reach the optimal size, workers' productivity is diminished, giving rise to a size-wage differential. Shi (2002) considers a direct search models in which a firm can hire a second worker but only after the first worker has been hired. While both workers have identical productivity, the presence of a second worker allows the firm to charge a higher price in the frictional goods market, giving rise to a positive size-wage differential. Lester (2010) studies a model in which firms can hire either one or two workers but focuses on the case of constant returns.

The paper is also related to the literature studying the sale of multiple items in a directed search framework. In Burdett et al. (2001) the market outcome depends on the number of units for sale at each seller but they assume that buyers' valuation are independent of the number of buyers at a seller's location. Geromichalos (2012) studies a directed search model in which sellers of goods post general trading mechanisms in which the price and quantity sold depend on the number of buyers. His focus is on describing the matching technology and while his setup allows for a positive consumption externality between buyers (corresponding to increasing returns) he does not explore that possibility in his analysis. Julien et al. (2014) explicitly focus on the case of a goods with positive consumption externality and show that the competing auction equilibrium is efficient with a negative reserve price.

The paper is organized as follows. In the next section, we develop and analyze a simple competing auction model of team production. In the subsequent section, we develop an extension of this basic model that allows for workplace competition between firms. The final section concludes.

2. Competing job auctions

This section solves the competing job auction model. Each firm has a technology that can employ a team of workers. The technology allows for synergies between workers. Therefore a larger team may have a higher average productivity than a smaller team. In such cases, it is necessary that the marginal product of additional workers will sometimes exceed the average product of the team.

2.1. The environment

Consider a matching market consisting of a continuum of workers, each providing one unit of labor, and a large number of firms. The workers are risk neutral, expected utility maximizers and the firms seek to maximize expected profits. The number of firms is determined by free entry. A firm that enters pays a fixed cost k. We let ϕ denote the number of firms who decide to enter the labor market. If n workers are used in production by a firm, the firm produces $f(n)$ units of output. For simplicity we assume that firm can utilize either one or two workers.

$$f(n) = \begin{cases} y_2 & \text{if} \quad n \geq 2 \\ y_1 & \text{if} \quad n = 1 \\ 0 & \text{if} \quad n = 0. \end{cases} \tag{1}$$

A worker who is not utilized by a firm produces b units of output.

Depending on the values of y_1, y_2 and b, different matching sets are feasible. Let $x \in \{0, 1, 2, \dots\}$ denote the number of workers assigned to a firm after the matching stage (described below). The output of an assignment of x workers to a firm is given by

$$z(x) = \begin{cases} bx & \text{if} \quad x \leq \underline{x} \\ f(x) & \text{if} \quad x \in \left[\underline{x}, \overline{x}\right] \\ f\left(\overline{x}\right) + b\left(x - \overline{x}\right) & \text{if} \quad x \geq \overline{x} \end{cases} \tag{2}$$

where $\underline{x}$ denotes the minimum team size for which $f(x) \geq bx$ and $\overline{x}$ denotes the maximum team size for which $f(x) - f(x-1) \geq b$. That is, if fewer than $\underline{x}$ workers are assigned to the firm, the workers will produce at home. On the other hand, if more than $\overline{x}$ workers are assigned to the firm, $n = x - \overline{x}$ will join the team and produce according to $f(n)$ and the remaining workers will produce b.

We let $AP(x) \equiv z(x)/x$ denote the *average product* of the assignment of x workers to firms. We also let $MP(x) \equiv z(x) - z(x-1)$ denote the marginal product of xth worker in an assignment of x workers to a team. We say that technology favors larger firms if $AP(2) > AP(1)$ and smaller teams if $AP(2) < AP(1)$. If the technology favors smaller teams, the marginal product of each team member is below the average product of the team; the standard case of global diminishing marginal returns for each worker hired. However, if the technology favors larger teams, the marginal product of the second team member exceeds the two-worker-team's average product, which is an example of local increasing returns.[7]

The nature of the team's returns to scale has implications for how the matching set of workers to teams $\{\underline{x}, \overline{x}\}$ changes as b increases. If

[3] A related analysis by Mortensen (2009) also points to the need to have a tax on entry. In Mortensen's "island matching" model, a match on an island can form only if the island attracts at least two participants (a firm and a worker). In our model, the islands are firms and a related tax is needed when synergies favor the creation of larger teams on each island.

[4] The amenities can be any feature of a workplace that augments the characteristics of the job from the point of view of the worker. For example, the firm could advertise that the job provides all the tools, clothes, etc. needed to complete the task. The firm could also advertise that the job includes a dental plan. The firm might also locate the task in a nice office in a nice neighborhood with a view overlooking a river.

[5] Lester et al. (2015) demonstrate that the zero reserve price result also critically hinges on the meeting technology between buyers and sellers.

[6] In addition to the papers discussed here, several other authors have developed search models with "large firms." These models typically feature a decreasing returns to scale production technology and are used for quantitative analysis. See, for example, Hawkins (2013) and Kaas and Kircher (2015) for models with a competitive search environment and Helpman et al. (2010) and Cosar et al. (2016) for models with a random search environment.

[7] This technology is consistent with a conventional U-shaped average cost curve for the production of output by a group where the costs are measured by the number of members in the group.