# THE EQUILIBRIUM ORGANIZATION OF LABOR

by

Birger Wernerfelt*

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* MIT Sloan School of Management, Cambridge, MA 02142, bwerner@mit.edu. This paper was written while the author visited the Department of Economics at the University of Copenhagen, whose hospitality is gratefully acknowledged. It reflects discussions with Tore Ellingsen, Bob Gibbons, Oliver Hart, Michael Rauh, and Steve Tadelis, as well as comments by seminar audiences at Berkeley, Chicago, CBS, Harvard, Imperial College, IIOC, MIT, NBER, Stockholm School of Economics, Toronto, and the University of Copenhagen. The usual disclaimer applies.

# THE EQUILIBRIUM ORGANIZATION OF LABOR


## Abstract

We look for the equilibrium organization of labor. The environment has two critical features: (a) Prior to working in a new plant, workers have to incur costs learning about local conditions. (b) Bilateral agreements are burdened by bargaining costs. Under weak conditions, markets, employment, and bilateral contracting dominate all other mechanisms. For each mechanism, we characterize the tasks traded in it, as well as the workers and manufacturers participating. Larger gains from specialization favor markets if firm sizes are fixed, but leads to larger optimal firm size. Lower trade barriers result in more market governance. The model does not rest on non-standard assumptions and its predictions depend on several factors that do not play a role in other contemporary theories of organization.

## I. INTRODUCTION

The advantages of specialization and the role of markets in supporting it have played a central role in economic reasoning at least since Adam Smith. A more recent, but still old stream of work has compared employment and contracts in agreements of their adaptive properties (Coase, 1937; Simon, 1951). We draw on both of these traditions to develop a unified theory of governance in the context of labor market equilibrium. Specifically, we first analyze a simple workhorse model with homogeneous tasks, manufacturers, and workers, showing that markets, employment, and bilateral contracting dominate all other mechanisms. Secondly, we introduce different kinds of heterogeneity and characterize the equilibrium mix of mechanisms and the types of tasks, manufacturers, and workers for which each is most efficient. Third, we characterize the optimal scope of the firm and find that larger gains from specialization may lead to less market governance. We finally show that markets are used more as barriers to trade are reduced.

Unlike many modern theories of economic organization the argument does not depend on non-standard assumptions such as behavioral biases, bounded rationality, heterogeneous beliefs, or incomplete contracting.

Many predictions of the model turn on a different set of factors than those highlighted in previous literature. Markets are preferred over bilateral mechanisms for tasks that take longer time to perform, are in less demand, and require less local learning, while employment is more efficient than bilateral contracting when needs change more frequently. Greater gains from specialization favors more market governance in a model with fixed firm sizes, but otherwise favor larger firms.

Larger firms hire specialist employees, firms of intermediate size hire generalist employees or go to the markets for specialists, and very small firms use the market exclusively. Experts work as specialist employees, then as market specialists, and finally as generalist employees in order of decreasing efficiency. Firms grow to take advantage of gains from specialization, but growth stops when the specialists have to work in too many different plants. Finally, markets become more prevalent with tariff agreements and the emergence of more efficient modes of transportation and communication.

To fix ideas, we will briefly discuss an example:

*Example.* We can illustrate several of the results by the use of repair labor in differently sized apartment complexes. A landlord who owns just one or two units will typically go to the market and hire specialists for everything from minor repairs ("toilet does not work") to smaller renovations ("install LED light bulbs in public spaces"). The units do not generate enough work to support an employee. On the other hand, the owner of a medium-sized building will typically have a generalist employee, the superintendent, perform minor repairs. The building generates a steady flow of small problems and the superintendent can solve each of them pretty well. Market specialists could do the jobs more easily, but is costly to pay for a new person to come in every time there is a problem. On the other hand, renovations such as electrical jobs are normally done by market specialists through the market. The jobs are larger, experts can do them better, and the building does not need a full time electrician. Finally, very large landlords, such as universities, normally use specialist employees for both repairs and minor renovations.

Major renovations or building projects, in which several tasks are bundled together, are typically governed by a bilateral contract regardless of the size of the landlord. The projects run for a finite time, each change may have significant implications for costs, and a lot of duplicate costs would be required to switch generalist contractors midstream. As a result, changes are typically managed though renegotiations with incumbent generalist contractors.

*Overview.* To understand all the moving parts of the model, consider a slightly more abstract example in which you are buying a sequence of labor services, "tasks", in a well-functioning market. Each task is bought from whoever can supply it at the lowest cost and the presence of alternative suppliers and buyers eliminates the scope for bargaining. However, in addition to the labor costs you have to pay for any specific investments the seller has to make in order for him to work at your "plant". While these investments include transportation costs, they are often associated with the seller's need to collect local information and we use the label "learning costs." They can be quite large. For example, if an executive is due to work as a country manager for a multinational firm, it may be necessary to use a lot of resources teaching the new hire about the company's way of doing business. There is no hold-up in the argument, but it is simply inefficient to incur learning costs on a very frequent basis.

If you need a very small task, the learning costs can be absurdly large relative to the gains from using a market specialist. A possible alternative is therefore to strike up a relationship

with a single seller who could work exclusively for you. This might be efficient under two conditions: First, that the tasks in question are of types for which the advantages of specialization are small, and second, that you need enough tasks to occupy him. A problem is, however, that the loss of market discipline opens the door for bargaining and burdens each purchase with some bargaining costs. If you have to bargain very frequently, it may be cheaper to pool the bargains into a single agreement under which you can have any task in a particular set for the same hourly price. The advantage of this arrangement, which we will think of as employment, is that adaptation is cheap: Relative to other bilateral mechanisms you can switch between tasks without incurring additional bargaining costs, and relative to the market, the employee avoids incurring learning costs at each turn.

If a manufacturer has large and regular needs for a specific task, she can take advantage of gains from specialization by hiring a specialist employee to perform just the task in question. A specialist employee will typically face intermediate learning costs: He will be working in more plants than a generalist, but in fewer plants than a market specialist. Specialist employees working with tasks in frequent demand, and thus in a relatively small number of plants, will create more value than market specialists. Manufacturers thus have an incentive to expand their scope in order grow large enough to hire specialist employees. As the scope of the firm grows, the employee specialists have to work in more different plants and thus will have to incur more learning costs. At some point, their costs are almost as high as those faced by market specialists or generalist employees and it is then not worth it to expand the firm any further.

*Frictions.* The results are driven by two frictions; one affecting markets and one affecting bilateral mechanisms. The frictions are (i) learning costs that are specific to each plant and (ii) subadditive bargaining costs. We will briefly discuss both.

(i) There are many costs and delays associated with changing places of work. The worker has to find the plant, physically get there, learn how things are done there, mesh schedules, and coordinate with other sellers. For most of the analysis we will use a single parameter for these learning costs, but they must be expected to vary all the way from transportation costs to absorption of corporate “culture”. In our workhorse model, reductions in learning costs have the same effect as increases in the cost advantage of experts. However, they play an independent and important role in bounding the scope of individual firms

(ii) We assume the existence of bargaining costs that are subadditive in the number of tasks covered by the agreement. While this clearly is an unusual premise, it is not unreasonable: Most people would rather bargain once over a $300 pie than 30 times over $10 pies. From a theoretical perspective, it is consistent with the rent-seeking literature (Tullock, 1967). More directly, Maciejovsky and Wernerfelt (2011) report on a laboratory experiment in which bargaining costs are found to be positive and subadditive.

*Focal mechanisms.* We first look at a model in which tasks, sellers, and manufacturers are statistically identical and all trades thus are governed in the same way. We show that three classes of mechanisms, suggestively labeled as the "Market", "Employment", and "Bilateral Contracting" , dominate a large class of alternatives.[1]

(1) In the "Market" mechanism, buyers take advantage of gains from specialization and trade with expert sellers who can meet their needs at the low costs. The Market functions without bargaining costs and no inefficiencies beyond the learning costs associated with the process of switching trading partners. Market payoffs thus differ from the highest possible by these learning costs only. A good example could be refrigerator repair: Experts can clearly perform the service much more efficiently than most laymen (such as a butler or a care-taker). Furthermore, the typical home-owner has the problem on a very infrequent basis, making it much cheaper to pay the transportation costs instead of hiring an appliance repairman to stand by at the house.

(2) In the "Employment" mechanism, the two players agree once-and-for-all on all components of a trading relationship. So there is only one round of bargaining, but often just average productivity (since all tasks are performed by a single player). However, sufficiently large manufacturers may be able to use individuals as specialist employees, performing only tasks within their expertise. The aforementioned superintendent illustrates the attractiveness of employment: In the typical case, so many things come up that it would be absurd to bargain on each occasion and many of the tasks are simple, such that an experienced "layman" can perform them with reasonable efficiency. Consistent with common terminology, Employment is a relationship in this model (Bartling, Fehr, and Schmidt, 2012). Linking to the famous example of Alchian and Demsetz (1972), the relationship between a boss and an employee is one in which a single wage has been agreed upon on a once-and-for-

[1] In an earlier version of the paper, a hybrid mechanism, "employment with wages set in the market" was shown to be dominant in a region of a richer parameter space.

all basis, while a buyer in a grocery store is confronted with new market prices in every period. The latter pair could in principle negotiate a complete long term contract, but bargaining costs will make this massively inefficient.

(3) In the ”Bilateral Contracting” mechanism, the two players agree to maintain a relationship for a while, but renegotiate each time the manufacturer needs a new service. Used instead of Employment when bargaining is rare, it shares the same advantages.

After identifying these three classes of dominant mechanisms in an economy with homogeneous trades and firms of fixed size, we proceed to introduce several types of heterogeneity and characterize the equilibrium mix between the market and employment sectors of an economy. If tasks differ, those with greater variance in costs, lower learning costs, and longer duration are traded in markets as opposed to from employees. If sellers differ, the most efficient experts will be working as specialist employees, those of medium efficiency will be market specialists, and workers with the weakest areas of expertise will be generalist employees. Manufacturers have incentives to grow larger by hiring specialist employees though the increased scope will force some specialists to work in a very large number of plants. The learning costs involved in this will in turn bound the size of the firm.

*Literature.* The paper links the classical literature on the division of labor with some strands of the modern literature on the theory of the firm. The former literature (Smith, 1965; Stigler, 1951; Rosen, 1978) has considered the effects of specialization and indivisibilities (Rosen, 1983). Rauh (2013) has taken this an important step further by looking at the implications of optimal incentives in firms and cooperatives. His model also incorporates the idea, from Becker and Murphy (1992), that firms expand to take advantage of gains from specialization. However, to the best of our knowledge, the present paper is the first to identify the optimal trading mechanisms in a model with advantages of specialization. The main payoff is a new set of predictions about the interaction between mechanisms and specialization. In particular, we compare market specialists with specialist employees and distinguish between different kinds of employment and bilateral contracting. Compared to the works of Oliver Williamson (e.g. 1985), the paper relies on a much smaller set of forces, all of which can be given a standard micro-foundation.[2]

[2] The model uses a reduced form representation of subadditive bargaining costs, but these can be micro-founded on standard assumptions. One possible such micro-foundation starts with two-sided incomplete information.

By looking at governance in the context of labor market equilibrium, the results contribute to the theory of integration at the industry level and bring in several new forces (advantages of specialization, aggregate demand for a task, size of manufacturer needs, the frequency with which needs change, the size of individual tasks, and the extent of job standardization). We are not aware of any other paper using this exact lens, but some come close. One recent stream (Grosman and Helpman, 2002; Legros and Newman, 2012; Ruzzier, 2011a, b; and Gibbons, Holden, and Powell, 2012) looks at governance in the context of output market equilibrium, while Garicano and Rossi-Hansberg (2006) look at organizational structure in the context of labor market equilibrium.

Unlike many recent theories of the firm, the argument made here does not depend on non-contractibility (Maskin and Tirole, 1999). Everything is in principle contractible, but bilateral contracting is costly thus causing complete long term contracts to be inefficient. Of course, the use of such contracting/bargaining costs have recent precedents in the literature (Bajari and Tadelis, 2001; Matouschek, 2004).

*Simplicity.* While the basic model deliberately is kept as simple as possible, this does not mean that it is unnecessary. The primary benefits of the model are to make the underlying assumptions precise, to give us a language for thinking about the forces driving the results, to suggest several testable propositions, and to prepare us for the more complicated analyses later in the paper. Even so, some of the comparative performance conditions in the Theorem would be difficult to derive without a formal model, as would the characteristics of dominant mechanisms.

*Vertical Integration.* As the title suggests, the paper is about the ways in which labor is traded, including the employment relationship. However, this has direct implications for vertical integration. The model defines the firm by the employment relationship and one firm is part of another if an only if one top-manager is an employee of the other. The prediction is then that the attractiveness of integration depends on the forces highlighted in the Theorem, notably the frequency with which needs change, the advantages of specialization, and the

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While this often leads to strategic bargaining costs (Myerson and Satterthwaite, 1983), these are typically not subadditive. However, if we allow bargainers to engage in costly attempts to learn the private information of their opponents, the resulting search costs may well be subadditive. So in the region in which bargainers chooses to search, we can have complete information bargaining with subadditive bargaining costs, just as assumed here (Wernerfelt, 2012).

learning costs. The former is tested by Novak and Wernerfelt (2012) and the latter plays a big role in the empirical literature on transaction-cost economics, while the effect of advantages of specialization awaits more empirical scrutiny.

*Horizontal Integration.* The theory suggests that different forces drive horizontal integration. As explained in Section V, firms may want to pursue horizontal integration in order to become large enough to be able to hire full time specialist-employees in more plants of work. On the other hand, this will ultimately force some specialists to work in a lot of different plants and incur the associated learning costs.

*Asset Ownership.* The analysis does not depend on assets, but the nature of the employment relationship has direct implications for asset ownership. For example, one could argue that the boss should own most productive assets since his decisions typically are the main determinant of the rate at which an asset is run down.[3]

*Plan of the Paper.* We formulate a very simple workhorse model in Section II and use it justify the focus on Markets, Employment, and Bilateral Contracting in Section III. Specifically, if tasks, manufacturers, and laborers are ex ante identical, it is shown that one of the three mechanisms listed above can govern all labor transactions in the economy more efficiently than any other mechanism in a large class. In Section IV, we look at different kinds of heterogeneity and characterize the market and employment sectors of an economy. The optimal scope of the firm and the allocation of talent in the economy are characterized in Section V and we finally look at trade in Section VI. Further research is discussed in Section VII. All proofs are relegated to the Appendix.

## II. WORKHORSE MODEL – FIXED FIRM SIZE

### II.1 *Basic elements of the economy.*

The model covers two time periods, $\tau = 1, 2$ and a unit payment in period *2* is worth $\delta \in (0, 1)$ in period *1*. Larger values of $\delta$ imply that periods are shorter, or equivalently, that changes are more frequent. There is a mass $S$ of *sellers* with generic element $s$ and a mass $M$ of *manufacturers* with generic element $m$.

[3] The theory is in Wernerfelt (2002), and a test is in Simester and Wernerfelt (2005).

The environment can be divided into more than *M plants.* In each plant there is, in each period, a single productive *task* that, if performed, will create one unit of output. These tasks are elements of a large finite set $\mathcal{T}$, where $|\mathcal{T}| = T$ and $t$ is a generic task. Sellers can perform one task per period and any seller can perform any task in $\mathcal{T}$. Each manufacturer has set of *S/M* plants and at the start of each period identifies, in each of these plants, the task that is productive in the period.

We will say that manufacturer *m needs* the productive tasks she identifies. The needs are not known in advance. We initially assume that all tasks are equally likely to be needed in every plant. Production cannot be expanded by performing a needed task more than once, or by performing an unneeded task.

Seller *s* bears positive effort costs every time he performs a task. His costs are *c* if he is a *layman* with respect to the task, but each seller is an *expert* in a particular task and his costs are *c** for that task. It will be convenient to assume that here are *S/T* experts in each task. The value of output is $v > c$. Players are risk neutral and total surplus is the sum of gains from trade less the costs of the two trading frictions discussed in Section I.[4]

Before a seller can start working in a new plant, he has to acquire some local knowledge. The costs *u* of this are borne by the owner of the plant and we refer to them as *"learning" costs* in the following. In Section IV, we will briefly allow these costs to vary between tasks, but for now we aim to keep things as simple as possible. To initialize the model and provide a starting point for the possible changes, sellers are randomly assigned to plants prior to period *1*. Since the learning costs incurred on that occasion are common to all mechanisms, we abstract from them.

Each time a seller engages in negotiations with a single manufacturer, the latter incurs *bargaining costs*. Bargaining costs are proportional to the number of agreements struck, but subadditive in the number of tasks covered by each agreement. More formally, if a seller-manufacturer pair makes a single agreement covering *T'* tasks, the manufacturer incurs total bargaining costs *K(T'),* where *K(T')* is positive, subadditive, and reaches its maximum $\overline{K}$ at $T_K < T$.

[4] Since the model does not depend on hold-up, we eliminate the possibility by assuming that the costs of frictions are borne by the manufacturers who, as the short side of the market, have bargaining power. We could interpret this literally or as a result of ex ante re-imbursements.

The subadditivity means that it is cheaper to negotiate a single price for several tasks than to agree on prices for each of them one-by-one. Since the players are risk-neutral and do not know which tasks will be needed in the next period, it never makes sense to negotiate more than one agreement per period, though possibly one covering many tasks.[5]

II.2 *Simple Mechanisms: Matching and Reaching Agreements.*

The processes for matching trading partners and agreeing on payments prior to trades are governed by a mechanism. A mechanism is *simple* if all trades are governed in the same way and $g$ denotes a generic simple mechanism. Since our workhorse model is based on ex ante identical players and tasks, one simple mechanism will be optimal for the entire economy.

Three types of costs are incurred in mechanisms: Production costs, learning costs, and bargaining costs. Production costs depend on the mechanism's ability to match manufacturer needs and seller expertise, and are thus determined by the sizes of the pools of sellers and manufacturers $(M_{g\tau}, S_{g\tau})$ , $\tau = 1, 2$, within which matching takes place and agreements are reached at the start of each period. For example, there can be no matching if $M_{g\tau} = 1$, perfect matching if $M_{g\tau} = M$, $S_{g\tau} = S$, and anything in between for different values of $(M_{g\tau}, S_{g\tau})$. Learning costs are incurred when and if players change plants between periods. The only reason to do so is to match needs and expertise. So the incidence of learning costs follows low production costs, reducing the net benefit to $c - c^* - u$. Bargaining costs are incurred in connection with the making of agreements when these involve a single manufacturer. For example, the parties can bargain over a specific task ($T_{g\tau} = 1$), over a blanket agreement covering all tasks ($T_{g\tau} = T$), or over anything in between for different values of $(T_{g1}, T_{g2})$. So we can summarize all payoff relevant information about a mechanism $g$ in the vector $(M_{g1}, M_{g2}, S_{g1}, S_{g2}, T_{g1}, T_{g2})$. Specifically, $(M_{g\tau}, S_{g\tau}, T_{g\tau})$ means that $M_{g\tau}$ manufacturers and $S_{g\tau}$ sellers are matched such that as many needs as possible can met by experts and otherwise by laymen, and that, as part of the matching process, each matched pair agrees on a single price for any of $T_{g\tau}$ tasks.

[5] One could, of course, also justify this by a complexity argument, as is done by Segal (1999) and Hart and Moore (1999).

Before searching over $(M_{g1}, M_{g2}, S_{g1}, S_{g2}, T_{g1}, T_{g2})$ to characterize the set of mechanisms capable of implementing all trades at the lowest possible total costs, we define three focal classes of mechanisms as follows: (All proofs are in the Appendix.):

Mechanisms in $\{M_{g1} = M_{g2} = M, S_{g1} = S_{g2} = S, T_{g1} = T_{g2} = 1\}$ are called *Markets*,

those in $\{M_{g1} = M_{g2} = 1, S_{g1} = S_{g2} = S/M, T_{g1} = T, T_{g2} = 0\}$ are called *Employment*, and

those in $\{M_{g1} = M_{g2} = 1, S_{g1} = S_{g2} = S/M, T_{g1} = T_{g2} = 1\}$ are called *Bilateral Contracting*.

**PROPOSITION 1:** *Markets, Employment, and Bilateral Contracting dominate all other classes and their costs are* $[c^* + u][1+\delta]$, $c[1+\delta] + \bar{K}$, *and* $[c + K(1)][1+\delta]$, respectively.

So the most efficient simple mechanism depends on four parameters $[c^* - c + u, \bar{K}, K(1), \delta]$.

Consistent with intuition and casual observation, the Market is better when the efficiency gap between experts and laymen is wider ($c^* - c$), when the learning costs are smaller ($u$)[6], when trade is less frequent/tasks take less time to complete ($\delta$), and when bargaining costs are larger. Employment is better than Bilateral Contracting when trade is frequent.

Some possible empirical implications of this are that tasks requiring more education are more likely to be performed by market specialists, that these account for more work in areas with greater population density, and that needs subject to frequent change are more likely to be met by employees.

## IV. CHARACTERIZING THE MARKET AND EMPLOYMENT SECTORS

We now introduce various kinds of heterogeneity such that the economy divides into sectors governed by different simple mechanisms. To this end, we assume that $\bar{K} < K(1)[1+\delta]$ and thus focus on the Market versus Employment choice.

### IV. 1. Two-sector model.

[6] *Fun fact.* A widely used definition of "civilization" holds that three properties are necessary: Urbanization, division of labor, and surplus from production (International Society for the Comparative Study of Civilizations, 2011). If we interpret $u$ narrowly as transportation costs, the Theorem portrays urbanization ($u$) and division of labor (Markets) as complements, and is thus consistent with the emergence of civilization.

We use $\mathcal{E}$ for the set of tasks governed by Employment, such that the set $\mathcal{T}\backslash\mathcal{E}$ is sourced in the Market. For any $\mathcal{E}$, equilibrium requires that a corresponding measure of sellers work as employees, while the rest are market specialists.

We define the mechanism and the equilibrium concept in the natural way:

*A mechanism with both Markets and Employment* is an extensive form game between *M* manufacturers and *S* sellers in which, prior to period *1*, each seller chooses whether to be a market specialist or an employee and each manufacturer decides which tasks to source from employees and which to get in the market. After that, the corresponding simple mechanisms are played.

*Definition.* An *equilibrium* is an allocation of sellers to simple mechanisms, market specialists to tasks, and employees to manufacturers such that

(i) All manufacturers have all needed tasks performed.
(ii) All sellers weakly prefer the simple mechanism to which they are allocated.
(iii) All manufacturers weakly prefer the mechanisms in which they get all tasks.
(iv) All employees weakly prefer the manufacturer to which they are allocated.
(v) All market specialists weakly prefer the task to which they are allocated.■

We can now look at several different types of heterogeneity. To keep the derivations uncluttered**,** we look at heterogeneity on a dimension-by-dimension basis.

IV.2. Heterogeneous tasks.

If the cost parameters differ between tasks, we can characterize those traded in the market and employment sectors of the economy as follows.

**PROPOSITION 2:** *If c*, u, and δ differ between tasks:*

*- Market specialists perform tasks in which experts' cost advantage over laymen, c – c* - u, is higher than* $\bar{K}/[1+\delta]$*, while all other tasks are performed by employees.*

*-Tasks with lower learning costs (less frequent change) are performed by market specialists, while those with higher learning costs (more frequent change) are performed by employees.*

To the extent that the learning costs simply are due to transportation, the intuition is that a market for market specialists will deliver tasks more efficiently in a city with smaller distances, and be less attractive in a rural area. So we should see more markets in cities and more relationships in rural areas (Chinitz, 1961). More generally, we would expect to see more employees when the learning costs are more substantial, such as those incurred in the process of learning how to serve a specific manufacturer. If $\delta$ is small, meaning that tasks take a long time, it is more attractive to use the market. On the other hand, if tasks are quick, the learning costs play a comparatively larger role. So we would expect to see employees meet quickly changing needs where the efficiency of adaptation matters more than the advantages of specialization.

The prediction about specific costs is shared with several other theories of organization and the effect of gains from specialization is that proposed by Adam Smith. However, the effect of the frequency of change is new. Novak and Wernerfelt (2012) find strong support for it in a large study of the automobile industry, but we are not aware of any studies looking at advantages of specialization and employment.

IV.3. Sellers differ.

While Proposition 2 is about heterogeneous tasks, we can prove parallel results if we instead allow sellers to differ.

**PROPOSITION 3:** *Suppose that expert costs are drawn IID from a uniform distribution with support* $[\underline{c}^*, \underline{c}^* + 1]$. *If* $c - \underline{c}^* - 1 - u < \bar{K}/[1+\delta] < c - \underline{c}^* - u$, *the more efficient sellers will work as market specialists and less efficient sellers will become employees.*[7]

We can also look at a case with heterogeneity in both tasks and sellers.

**PROPOSITION 4***: Suppose that demand* $D_t$ *(measure of aggregate manufacturer needs) differs between tasks and that expert costs are drawn IID from a uniform distribution with support* $[\underline{c}^*, \underline{c}^* + 1]$.

*-Among the tasks for which demand is less than or equal to S/T; if*

$$(1) \qquad \underline{c}^* + D_t T/S + u \leq c + \bar{K}/(1+\delta),$$

[7] Similar results obtain elsewhere in the parameter space. For example, if Bilateral Contracting is dominant.

*all needs are met by market specialists. If (1) does not hold, but*

$$(2) \qquad \underline{c}^* + u \leq c + \overline{K}/(1+\delta),$$

*needs are met by a mixture of market specialists and employees. If (2) does not hold, all needs are met by employees.*

*-Among the tasks for which demand is larger than S/T; if (2) holds, needs are met by a mixture of market specialists and employees, and if (2) does not hold, all needs are met by employees.*

Intuitively, low demand tasks can be performed by market specialists because the market price, reflecting the costs of the least efficient market specialists, is low.

## V. THE SCOPE OF THE FIRM AND THE ALLOCATION OF TALENT

### V. 1. The scope of the firm.

While manufacturers' sizes so far have been assumed to be fixed, we now look at the optimal scope of the firm. To this end, we allow manufacturers to have some *stable needs* in the sense that they are sure to need one or more sellers to meet these specific needs in every period, though possibly in different plants. This framework allows us to analyze the use of *specialist employees*, who perform tasks for a single manufacturer in return for a once-and-for-all negotiated wage, but concentrates all of their work on one task. The key difference between this case and those considered beforehand, is that specialist employees will work in different plants, though normally not in as many as market specialists. Because the specialist employee has a better chance of visiting the same plant twice, the expected learning costs are smaller than those incurred by market specialists.

The extensive form is the same as before, except that sellers now decide between careers as market specialists, specialist employees, or generalist employees, while manufacturers decide which tasks to acquire from each of these three types of sellers. The equilibrium concept is similarly extended:

*Definition.* An *equilibrium with some stable needs* is an allocation of sellers to simple mechanisms, market specialists to tasks, and employees to manufacturers, such that

(i) All manufacturers have all needed tasks performed.

(ii) All sellers weakly prefer the simple mechanism to which they are allocated.

(iii) All manufacturers weakly prefer the mechanisms in which they get all tasks.

(iv) All employees and specialist-employees weakly prefer the manufacturer to which they are allocated.

(v) All market specialists and specialist employees weakly prefer the task to which they are allocated.■

A firm that expands its scope to include enough plants could hire specialist employees and send them from plant to plant as needs dictate. Since these have costs $c^*$ rather than $c$, the incentives for expansion are clear. However, such specialist employees would need to incur learning costs for all the firm's plants, and while market specialists visit even more plants, negotiations with them are not burdened by bargaining costs. So at some point, the specialist employees cease to be more efficient than market specialists or generalist employees. More formally, define $q_t$ as the number of plants in which a specialist employee has to work in order to be fully utilized. Such an expert will have costs $c^* + ug(q_t)$ where $g(\ )$ is increasing in $q_t$ and takes values between $0$ and $1$.

**PROPOSITION 5:** *The scope of the firm is bounded at* $q^* \in \{q_t \mid t \in \mathcal{T}\}$ *given by*

$$(3) \qquad c^* + ug(q^*) + \bar{K}/(1+\delta) = MIN\{ c + \bar{K}/(1+\delta),\ c^* + u\}$$

*Remark.* If generalist employees are the best alternative, *(3)* reduces to $q^* = g^{-1}([c-c^*]/u)$ and the scope of the firm is larger when gains from specialization are larger. So when firm size is endogenous, the model turns on its head Adam Smith's famous intuition about gains from specialization and markets.[8] The effect of increased learning costs depends on the best alternative in *(3).*

The incentives to expand are reminiscent of prescriptions from the managerial literature on corporate strategy according to which firms should change their scope to leverage excess capacity of productive resources - thereby eliminating this excess and focusing on "what they are good at." In Edith Penrose's (1959) original formulation of this idea, the excess capacity is tied to the time of individual managers; much like the above argument is driven by the efficiency gains from fully utilizing specialist employees. While we will not pursue it here,

[8] See also Rauh (2013) and the references therein.

the argument could easily be extended to cover groups of employees with complementary skills.

The limit to expansion are driven by the specialist employees becoming more and more like market specialists as the scope of the firm grows. Coordination becomes expensive as they enter new assignments without a store of local knowledge and at some point it becomes cheaper to use local generalists or market specialists.

If we define similarity between plants by overlaps in the local knowledge necessary to perform tasks, the Proposition suggests that firms will expand to similar plants and stop expanding before their scope becomes too unfocused. This would suggest that costs decrease with volume within an industry, but increase with the extent of inter-industry diversification, in line with empirical results (Hortacsu and Syverson, 2007; Atalay, Hortacsu, and Syverson, 2013; Montgomery and Wernerfelt, 1988; Wernerfelt and Montgomery, 1988).

V. 2. The allocation of talent.

Proposition 5 implies that $\bar{K}/(1+\delta) < u[1 - g(q^*)]$ for all firms and thus for all employee specialists. We can use this fact to understand the allocation of talent in the economy.

We will describe an efficient outcome and show in the Appendix that it is an equilibrium. As before, we assume that expert costs for all tasks follow a uniform distribution with support $[\underline{c}^*, \underline{c}^* + 1]$ and that total needs for each task are the same.[9] Consider the task $t$ and the seller $s$. The total two-period costs if $s$ is a specialist employee, a generalist employee, and a market specialist are $(1+\delta)[c_{st}^* + ug(q_t)] + \bar{K}$, $(1+\delta)c + \bar{K}$, and $(1+\delta)[c_{st}^* + u]$, respectively. The social return to lower $c_{st}^*$ is the same for specialist employees and market specialists, but as, by Proposition 5, $\bar{K}/(1+\delta) < u[1 - g(q^*)]$, the former create more surplus. Since the stronger seller types can offer manufacturers more, the most efficient sellers will work as specialist employees on $t$. The next most efficient group will then be market specialists, while generalist employees come last.

More completely, for this model we have

[9] This assumption means that we forego analysis of the effects of demand differences in this Section. A simple extension would, for example, suggest that tasks with very low demand are supplied by market specialists only. (Since no manufacturer will have large enough needs to justify hiring a specialist.)

**PROPOSITION 6:** *If manufacturers have some stable needs, tasks have identical cost distributions, and total demand for each task is the same, there exists an equilibrium in which*

*(a) if* $\underline{c}^* + u < c + \bar{K}/(1+\delta) < \underline{c}^* + 1 + u$, *manufacturers use specialist employees for stable needs and a mixture of generalist employees and market specialists for other tasks,*

*(b) if* $\underline{c}^* + 1 + u < c + \bar{K}/(1+\delta)$, *manufacturers use specialist employees for stable needs and market specialists for other tasks,*

*(c) if* $\underline{c}^* + ug(q_t) < c + \bar{K}/(1+\delta) < \underline{c}^* + u$, *manufacturers use specialist employees for stable needs and generalist employees for other tasks,*

*(d) if* $c + \bar{K}/(1+\delta) < \underline{c}^* + ug(q_t)$, *manufacturers use generalist employees for all tasks, and*

*(e) in order of decreasing efficiency, sellers become specialist employees, market specialists, and generalist employees.*[10]

The first part of this prediction appears to contrast with that of Garicano (2000). In his model, legal skills are ordered along a single dimension and the best lawyers perform the most difficult tasks. If we make the additional assumption that the most difficult problems these come up infrequently, the best lawyers will work as market specialists rather than in firms. In the present model, there are manufacturers with full-time needs for each skill. In areas of law in which many firms use specialist employees, those will be the best lawyers. However, in those branches of law in which only very large firms can sustain specialist employees, the best lawyers work in law firms.

The Proposition thus explains why more focused firms employ specialized labor, such as lawyers and plumbers, which more diverse firms hire market specialists on a case-by-case basis.

[10] The proof consists of a fee, wage and payment schedule that implements the equilibrium. Since the wages and payments result from decentralized negotiations, it is hard to argue that these particular values will be agreed on. However, it will be clear that many different wage and payment schedules implement the same equilibrium.

## VI. TRADE AND DISTANCE

We can model tariffs and geographical distances in the workhorse model by letting the learning costs depend on the identities of each (seller, manufacturer) pair. As a simple example, suppose that the economy is divided into two clusters, one with all sellers who are experts in tasks $t \in \mathcal{T}'$ together with $M \left| \mathcal{T}' \right| / T$ manufacturers and another with all the other agents (and thus all sellers who are experts in tasks $t \in \mathcal{T} \backslash \mathcal{T}'$). Suppose further that the learning costs between $s$ and $m$, $u_{sm} \in [\ \bar{K}/(1+\delta),\ c - c^* + \bar{K}/(1+\delta)]$ if $s$ and $m$ are in the same cluster and infinitely large otherwise. In this case only some sellers can work as market specialists while the rest will be employees. However, if the clusters are merged, all sellers will become market specialists.

**FINDING**: *If barriers between initially unbalanced clusters are reduced, more sellers become market specialists and fewer remain employees.*

So beyond increasing specialization, trade also affects the mechanisms through which agents sell their labor. Specifically, the making of tariff agreements and the emergence of trains, cars, and electronic communication should cause a shift towards market governance.

## VII. CONCLUSION

We have characterized the equilibrium use of markets, employment, and bilateral contracting, as well as the tasks, sellers, and manufacturers for which each is most efficient. Many of the predictions are easily testable and factors like the advantages of specialists, the frequency of change, the magnitude of demand, the size of firms, and the size of tasks, are particularly interesting since they do not appear in other contemporary theories of organization.

In terms of future research, the workhorse model is deliberately very simple and can easily be extended in any number of directions. One could, with very little effort, look at multiple categories of needs, complementarities between needs, broader areas of expertise, investments in physical assets, and incomplete information. A more difficult, but seemingly doable, extension is to allow players to invest in their level of skill.

A less direct extension would be to look at the economy's ability to absorb various shocks. The use of the generalist/specialist employees is main novelty of the model and the fixed up front costs $\bar{K}$ make these mechanisms less flexible than the market (Rosen, 1968).

Anticipating problems in case of a negative shock, manufacturers may be reluctant to invest in hiring, preferring instead to fill in with market specialists or generalist-contractors. The workhorse model in the present paper cannot be used to investigate this in any detail, but it seems at least conceivable that a suitable extension could contribute some foundations to the study of labor demand over the business cycle.

## APPENDIX: PROOFS

Proof of Proposition 1

**PROOF:** Note first that the optimal $S_{g\tau}$, $= M_{g\tau}\, S/M$, since we otherwise end up with some unmatched sellers. Next, let $p(M_{g\tau})$ be the probability that a randomly chosen manufacturer is matched with an expert. This is monotonically increasing in $M_{g\tau}$ and costs are $[1-p(M_{g\tau})]\, c + p(M_{g\tau})\, [c^* + u]$ if $M_{g\tau} > 1$ and independent of $p$ if $M_{g\tau} = 1$.So the optimal $M_{g\tau}$ is either $1$ or $M$.

Now assume that $M_{g1} = 1$, and use that $T_{g1}/T$ is the probability that a randomly chosen period $2$ task is covered by the period $1$ agreement. Costs in period $2$ are $[c + K(1)][1-T_{g1}/T] + cT_{g1}/T + K(T_{g1})/\delta = [1-T_{g1}/T]\, K(1) + c + K(T_{g1})/\delta$, and since the second derivative is negative, this is minimized for $T_{g1} = T$ or $T_{g1} = 1$. In the former case no further negotiations are necessary (because the agreement covers the manufacturer's needs in period $2$), but in the latter case each seller has to negotiate an agreement about the need he is to meet in period $2$. So if $M_{g1} = 1$, we are left with only two possibilities:

$M_{g1} = M_{g2} = 1$, $S_{g1} = S_{g2} = S/M$, $T_{g1} = T_{g2} = 1$.

$M_{g1} = M_{g2} = 1$, $S_{g1} = S_{g2} = S/M$, $T_{g1} = T$, $T_{g2} = 0$.

Suppose finally that $M_{g1} = M$ such that there are no bargaining costs. In this case, we might as well set $T_{g1} = T_{g2} = 1$. So if $M_{g1} = M$, we are also left with only one possibility

$M_{g1} = M_{g2} = M$, $S_{g1} = S_{g2} = S$, $T_{g1} = T_{g2} = 1$.■

Proof of Proposition 2

Since the two parts are proved by similar arguments, we only explicate the first:

Experts at $t$ will prefer to charge $f_t$ as market specialists rather than being paid $w$ as employees if:

$$(A1) \qquad f_t - c^* \geq w - c = 0$$

So the supply of market specialists, $x(f_t,)$, is

$$(A2) \qquad x_t(f_t,) = S/T \qquad \text{if } f_t \geq c^* \text{ and } 0 \text{ otherwise}$$

The demand for market specialists, $y_t(f_t,)$, *is* also a one-step function. A manufacturer will prefer to use a market specialist to perform task *t* if this is cheaper than asking an employee to do it. So

*(A3)* $y_t(f_t,) = S/T$ if $f_t + u \leq c + K(|\varepsilon|)/(1 + \delta)$ and *0* otherwise.

Depending on the relationship between the functions *(A2)* and *(A3)*, there are two classes of equilibria: If $c^* + u - c \leq \bar{K}/(1 + \delta)$, *t* would be performed entirely by market specialists, while if $c^* + u - c > \bar{K}/(1 + \delta)$, *t* would be performed entirely by employees. (An employee will have just enough work on the average, but depending on the stochastic needs of his employer, may occasionally need to perform more or less than one task per period.) ■

Proof of Proposition 3

As in the proof of Proposition 2, the demand for market specialists will be a one-step function, but the supply will now be a piece-wise linear function with a monotonic middle part. The premise in the Proposition is that they intersect on the middle part. ■

Proof of Proposition 4

Consider first the tasks for which $D_t \leq S/T$. In this case the cost of the marginal expert would be $\underline{c}^* + D_t T/S$ and he will prefer being a market specialists over being an employee if

*(A4)* $f_t - \underline{c}^* - D_t T/S \geq w - c.$

Suppose that $w = c$ and that $f_t = \underline{c}^* + D_t T/S$. The task *t* will be supplied entirely by market specialists if the cost of hiring the least efficient market specialists is smaller than that of hiring an employee, or if

*(A5)* $\underline{c}^* + D_t T/S + u \leq c + \bar{K}/(1 + \delta).$

If *(A5)* does not hold, the best experts will still prefer working as market specialists as long as

*(A6)* $\underline{c}^* + u < c + \bar{K}/(1 + \delta).$

However, in this case the rest of the tasks would be performed by employees. If *(A6)* does not hold, all tasks are performed by employees.

The tasks for which $D_t > S/T$ cannot be fully supplied by experts and the fee $f_t$ would be bid up to $c$. Some experts will prefer to work as market specialists as long as *(A6)* holds and all will prefer to do so if

*(A7)* $\underline{c}^* + 1 \leq c$.■

Proof of Proposition 6

Since all tasks are statistically identical, fees, salaries, wages, and quantities will be the same for all $t$. We define $w_t$ as the negotiated salary of a specialist employee, while using $f_t$ as the fee of a market specialists, and $w$ as the negotiated salary of an employee. The postulated equilibrium is implemented by prices meeting following IR- IC conditions*:*

The marginal specialist employee, who has cost $c^{\#\#}$, is indifferent between that and being a market specialists if

*(A8)* $w_t = f_t$,

and the marginal market specialists, who has cost $c^{\#}$, is indifferent between that and being an employee if

*(A9)* $f_t - c^{\#} = w - c$.

There are two IC constraints for the manufactures. They prefer specialist-employees over market specialists for their full-time jobs if

*(A10)* $w_t + ug(q_t) + \bar{K}/(1 + \delta) \leq f_t + u$

and they are indifferent between market specialists and employees for jobs with small demand if

*(A11)* $f_t + u = w + \bar{K}/(1 + \delta)$

The IR constraints for the three groups of sellers are

*(A12)* $w_t \geq c^{\#\#}$ (where $c^{\#\#} \geq c^{\#}$)

*(A13)* $f_t \geq c^{\#}$, and

*(A14)* $w \geq c$.

Finally, the IR constraints for the manufacturers are

*(A15)* $v \geq w_t + ug(q_t) + \bar{K}/(1 + \delta)$

*(A16)* $v \geq f_t + u$, and

*(A17)* $v \geq w + \bar{K}/(1 + \delta)$.

Since *(A12) – (A17)* can be met simply by raising the levels of $w_t$, $f_t$, $w$, and $v$, we focus on *(A8) – (A11).* The first two conditions are satisfied by $f_t = w_t = c^{\#}$ and $w = c$.

Since we are looking at the case in which $u\,[1 - g(q_t)] > \bar{K}/(1 + \delta)$, these also insure that *(A10)* is met and they meet *(A11)* for $c^{\#} = c - u + \bar{K}/(1 + \delta)$.

So the proposed fees and wages implement an equilibrium. ■

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