THE EQUILIBRIUM ORGANIZATION OF LABOR

by

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THE EQUILIBRIUM ORGANIZATION OF LABOR

Abstract

We look for the equilibrium mix of trading institutions when manufacturers need sequences of labor services. The environment has two critical features: (a) Multilateral matching allows gains from specialization, but players incur specific set-up costs each time they are matched with a new trading partner. (b) Bilateral relationships economize on set-up costs, but are burdened by bargaining costs. Under weak conditions, four mechanisms weakly dominate all others: Markets, employment with negotiated wages, employment with market wages, and bilateral sequential contracting. In labor market equilibrium, markets are used for services that take longer time to perform, are in less demand, require fewer partner-specific investments, and have larger cost differences between sellers. The most efficient sellers work as specialist employees, those of medium efficiency sell their services as professionals in markets, and the least efficient become employees. Large firms hire specialists, medium-sized firms use employees or the market, and small firms use the market exclusively. Lowered trade barriers cause a shift towards market governance.

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 terms of their adaptive properties (Coase, 1937; Simon, 1951). We here combine both concerns to develop a theory of governance in the context of labor market equilibrium. Specifically, we first analyze a simple workhorse model with homogeneous tasks, manufacturers, and laborers, showing that four mechanisms; markets, employment with negotiated terms, employment with wages set in a market, and sequential contracting, weakly dominate all others. We then introduce different kinds of heterogeneity and characterize the equilibrium mix of mechanisms and the products, laborers, and manufacturers for which each is most efficient.

Markets are preferred over bilateral mechanisms for services that take longer time to perform, are in less demand, require fewer partner-specific investments, and have larger cost differences between experts and others. Employment is more efficient than sequential contracting for services that take less time to perform, and market wages are used for jobs with more standardized terms. The equilibrium prevalence of each mechanism reflects the relative incidence of services with these properties.

In order of decreasing efficiency, experts work as specialist employees, then as professionals in markets, and finally as employees. Larger firms hire specialists, firms of intermediate size hire employees or go to the markets for professionals, and very small firms use the market exclusively. Finally, Markets become more prevalent with tariff agreements and the emergence of more efficient modes of transportation and communication.

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 professionals 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 an 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. Professionals 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 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, typically use specialist employees for both repairs and minor renovations. Major renovations or building projects, in which several services 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 contractors midstream. As a result, changes are typically managed though renegotiations with incumbent contractors.

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 in a well-functioning market. Each service is bought from whoever can supply it at the lowest cost and the presence of alternative suppliers pushes price down to marginal costs while eliminating the need for bargaining. However, in addition to the marginal labor costs you have to pay for any co-specific investments you and the seller have to make in order for him to serve you. For a plumber these investments are mostly travel costs, but 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 set-up costs on a very frequent basis. If you need a very small service, these costs can be absurdly large relative to the gains from specialization. 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 services in question are of types for which different sellers have more or less identical costs, and second, that you need enough services 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 service 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 services without incurring additional bargaining costs, and relative to the market, the employee avoids incurring set-up costs at each turn. All employment relationships require some bilateral negotiation of terms, but if the job is relatively standard, wages could be set by market forces.

If a manufacturer has large and regular needs for a specific task, she can take advantage of the gains from specialization without having to pay a lot of set-up costs by hiring a specialist employee to perform just the task in question. Since specialists create more value than anybody else, these positions are taken by sellers who are even more efficient than those who become professionals. Furthermore, manufacturers have an incentive to expand their scope in order grow large enough to hire specialists.

Beyond the standard assumption that different sellers have different costs, the results are driven by two frictions; one affecting markets and one affecting bilateral mechanisms. The frictions are (i) set-up costs that are specific to each seller-buyer match and (ii) sub-additive bargaining costs. We will briefly discuss both.

(i) There are many costs and delays associated with changing trading partners of labor (human asset services). The parties have to find each other, physically get together, learn how their new partners do things, mesh schedules, and coordinate with other sellers. For most of the analysis we will use a single parameter for these ”specific set-up” costs, but they must be expected to vary all the way from transportation costs to absorption of corporate “culture”.

(ii) We assume the existence of bargaining costs that are increasing in the number of tasks covered by the agreed upon terms of trade. While this clearly is a controversial component of the model, increasing bargaining costs are 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 sub-additive.[1]

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 four specific mechanisms, suggestively labeled as the “Market”, “Employment”, ”Sequential Contracting” , and “Employment with Market Wages”, weakly dominate a large class of alternatives.

(1) In the “Market” mechanism, the buyers take advantage of gains from specialization and trade with whichever seller can meet their needs at the lowest costs in any given period. The Market functions without bargaining costs and no inefficiencies beyond the specific set-up

[1] One possible theoretical micro-foundation, based only on standard assumptions, starts with two-sided incomplete information. While this often leads to strategic bargaining costs (Myerson and Satterthwaite, 1983), these are typically not sub-additive. 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 sub-additive. So in the region in which bargainers chooses to search, we can have complete information bargaining with sub-additive bargaining costs, just as assumed here (Wernerfelt, 2011).

costs associated with the process of switching trading partners. Market payoffs thus differ from the highest possible by these specific set-up 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 normally just average productivity (since all tasks are performed by a single player). However, sufficiently large manufacturers may be able to use individual employees as specialists, 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.

(3) In the ”Sequential 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.

(4) In the “Employment with Market Wages” mechanism, players first participate in a multilateral job market in which wages are determined without bargaining costs. Sellers and manufacturers are then matched such that the first task needed by the manufacturer is one the seller can perform at very low costs. Because later tasks are unknown, the parties still have to customize the non-wage components of the employment relationship, but these costs are smaller. This mechanism then allows some specialization, requires some bargaining costs, and sacrifices some gains from trade.

After identifying these four weakly dominant mechanisms in an economy with homogeneous trades, we proceed to introduce several types of heterogeneity such that different mechanisms are used in different sectors of the economy. If tasks differ, those with greater variance in costs, lower specific set-up costs, and longer duration are traded in markets as opposed to from employees. If sellers differ, the most efficient among them will generally work as professionals as opposed to employees. Furthermore, tasks in less demand are performed by the most efficient sellers working as professionals or by a mixture of professionals and employees. If manufacturer sizes differ, the largest ones will hire specialist employees, and the smallest will use the market.

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), but the present paper is, to the best of our knowledge, the first to combine these and other frictions with an explicit consideration of alternative mechanisms. The main payoff is a new set of predictions about the interaction between mechanisms and specialization. In particular, we compare professionals in markets with specialists in bilateral relationships and distinguish between different kinds of employment and sequential contracting.

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, 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, 2009; Ruzzier, 2011a, b; and Gibbons, Holden, and Powell, 2011) 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 (Grossman and Mart, 1986; Maskin and Tirole, 1999). On the other hand, the use of contracting/bargaining costs have recent precedents in the literature (Bajari and Tadelis, 2001; Matouschek, 2004).

We formulate a very simple workhorse model in Section II and use it justify the focus on Markets, Employment, Sequential Contracting, and Employment with Market Wages in Section III. Specifically, if tasks, manufacturers, and laborers are ex ante identical, Proposition 1 states that one of the four mechanisms listed above will govern all labor transactions in the economy. In the next four Sections, we introduce different kinds of heterogeneity while maintaining labor market equilibrium. In Section IV, we look at heterogeneity in tasks and characterize the equilibrium mix of mechanisms and the tasks that are traded in each. Section V looks at similar questions but focuses on the use of different mechanisms by different sellers. The same question is then asked for differently sized manufacturers in Section VI, while Section VII considers trade and Section VIII looks at manufacturers' incentives to change their scope. Further research is discussed in Section IX.

II. WORKHORSE MODEL

II.1 *Basic elements of the economy.*

We look at an economy in which a single output is produced with labor as the only input. The environment changes over time and in each state there are several different ways to use labor productively. All agents sell their labor, but some are *manufacturers* who work for themselves and buy additional labor based on their production possibilities.

More formally, there is a mass $S + M$ of laborers, S are *sellers* with generic element s and M are manufacturers with generic element m. (Though we will abstract from integer problems throughout, it will, in some of the following, be natural to think of S/M as a natural number.) There are three time periods, $\tau = 0, 1, 2,$ although the first is for initialization only. The period 1 value of a unit payment in period 2 is $\delta \in (0, 1)$. Larger values of δ imply that periods are shorter, or equivalently, that changes are more frequent. In each period, a laborer can perform any task in $\mathscr{T}$, where $|\mathscr{T}| = T$ is a large (uncountable) number, and t is a generic task. Players can contract on individual tasks and sets of tasks, but not beyond a finite number.

To produce output, each manufacturer *needs* several tasks each period. Needs are not known in advance and change between periods. A manufacturer produces one unit of output in every period in which a seller performs one needed task for her and production cannot be expanded by performing a needed task more than once, or by performing an unneeded task. Each seller can perform an average of one task for one manufacturer per period and manufacturers work for themselves, performing tasks other than those considered here. The production technology is such that manufacturer m in each period draws N_m tasks from a multinomial distribution with probabilities $\boldsymbol{n_m} = (n_{m1} \,..,n_{mt} \,..,n_{mT})$, where for most of the paper $n_{mt} = 1/T$, and m drawing task t means that she needs someone other than herself to perform it. We use $\boldsymbol{n^{m\tau}} \in \{0, 1\}^T$ to denote m's needs in period τ. We assume that $\int_m N_m n_{mt} = S/T$ such that the labor market clears.

Seller s bears positive effort costs every time he performs a task. Each s is an *expert* at performing one task, $t^*(s)$, and there is an equal mass of experts S/T at each task, such that all needs in principle could be met by experts. The cost of performing $t^*(s)$ is c^*. For $t \neq t^*(s)$, s is a *layman* and all these tasks cost $c > c^*$. The value of output is exogenously set at $v > c$.[2]

Total surplus is the sum of gains from trade less the costs of two trading frictions.[3]

(1) If a seller is re-matched (switches) from one manufacturer to another, the new manufacturer incurs some strictly positive seller-specific costs u; referred to as *"specific set-up" costs* in the following. These costs are incurred prior to the task being performed. In Section IV, we will briefly allow them to vary between tasks, but for now we aim to keep things as simple as possible. As a starting point for the possible re-matches, sellers and manufacturers are initially matched by expertise and period *0* needs.

(2a) Each time a seller engages in negotiations with a single manufacturer, the latter incurs *bargaining costs*. Specifically, suppose that a single manufacturer negotiates with $S_g \in Z_+$ sellers each of whom agrees to $P_g \in Z_+$ terms of trade including prices covering $T_g \in Z_+$ tasks. In that case the manufacturer incurs total bargaining costs $P_g K(T_g)$ per seller, where $K(T_g)$ is positive, concave, and reaches its maximum $\bar{K}$ at a finite value of T_g.

(2b) No costs are incurred in negotiations/trades between a seller and two or more manufacturers. However, some costs are incurred if prices are negotiated in a multilateral setting while other aspects of trade are agreed upon in a bilateral setting. The idea is that the parties need to customize details of the contract to local conditions. For standardized jobs this may be a very small effect and positions can be filled by advertising a wage. However, no executive, salesperson, or staffer will take an open ended job without knowing a lot about its

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[2] A minor reformulation of the model could accommodate an interpretation in which experts have the same per-period costs as laymen but produce units of higher value (or more than one unit).

[3] 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.

content. We use $H() \leq K()$ to denote the costs of negotiating non-price terms of trade and assume that $H()$ has the same properties as $K()$,and thus reaches its maximum $\overline{H}$ at a finite value of T_g.

The model is most interesting if $(1 + \delta)u > \overline{K}$. In the following Sections, we will define markets and employment in such a way that this inequality implies that employment adapts more cheaply than markets. Since the latter benefit from specialization, we have a tradeoff.

II.2 *Mechanisms and game forms.*

Agents explore and consummate trades by participating in one or more *mechanisms.* A "*game form*," which can be seen as the organization of the economy, specifies a set of *mechanisms*, such as markets and employment, and allows the players to sort between them. A seller will only participate in one, but a manufacturer can choose to meet different needs in different mechanisms. For example, each seller has to choose how to sell his labor, while a manufacturer may get some services in the market and others from employees.

We need a bit of machinery to formally introduce mechanisms and game forms.

The *sequence of informational events* in the economy is as follows:

In period *0*:

Sellers' areas of expertise $t^*(s)$ are realized along with manufacturer needs for the period, $\boldsymbol{n}^{m0}$. Sellers and manufacturers are matched accordingly.

In each period $\tau = 1, 2$.

$\tau.1$. All manufacturers' needs $\boldsymbol{n}^{m\tau}$ are realized.

$\tau.2$. If trade is agreed, sellers perform their tasks, and payments are made.

In this paper, a "*mechanism*" defines a trading game based on this basic sequence by adding intermediate stages at which players, in each period and for each service, can match and arrive at terms of trade. Mechanisms, such as employment and markets, do not sort players into groups playing different sub-games; that happens in game forms. That is, a game form may give players a choice between two or more mechanisms.

Let $\boldsymbol{\Gamma}_{\tau-1}$ be the $M_g \; x \; S_g$ matrix describing last period's matches between manufacturers and sellers, while $\boldsymbol{n}^{g\tau}$ is the $|\mathcal{T}_g| \; x \; M_g$ matrix of current needs, $\boldsymbol{c}^g$ is the $|\mathcal{T}_g| \; x \; S_g$ matrix of costs, and $\boldsymbol{\pi}_\tau$ is a $|\mathcal{T}_g| \; x \; M_g$ matrix of current prices.

Definition. An extensive form game is *primitive* if all players participate in identical sub games.■

Definition. A mechanism g governing a sequence of trades in a set of tasks $\mathcal{T}_g \in \{0, 1\}^T$ between $M_g \in Z_+ \cup (0, M]$ manufacturers and $S_g \in Z_+ \cup (0, S]$ sellers is a primitive extensive form game which includes the sequence of informational events. Any Nash equilibrium, $\mathcal{E}_g(\boldsymbol{\Gamma}_{\tau-1}, \boldsymbol{n}^{g\tau}, \boldsymbol{c}^g) = (\boldsymbol{\Gamma}_\tau, \boldsymbol{\pi}_\tau)$, specifies which (if any) seller meets each need and at what price.■

Processes for determining prices are an important component of any mechanism. Since contemporaneous information is perfect and information about the future is symmetric, there are many efficient price determination processes. In the following, we use take-it-or-leave-it (TIOLI) offers by manufacturers as an example.

In the economy defined here, a small number of attributes determine how much surplus can be created by the players using a mechanism. We explain this in three steps but first define a *trading efficient mechanism* as follows:

Definition. A mechanism governing a sequence of trades in all $t \in \mathcal{T}$ between $M_g \in Z_+ \cup (0, M]$ manufacturers and $S_g \in Z_+ \cup (0, S]$ sellers is *trading efficient* if it has a Nash equilibrium that maximizes gains from trade between the $M_g + S_g$ players. ■

Note that the definition refers to trades between the subset of players using the mechanism. Mechanisms with more participants will be able to match supply and demand better and implement larger gains from trade. The key point is that the gains from trade implemented by a trading efficient mechanism depend on (M_g, S_g) only.

Second, all manufacturers incur specific set-up costs depending on whether players change their trading partners for periods *0* and *1* and/or between periods *1* and *2*. Any Nash equilibrium of a mechanism *g* with $M_g > 1$ defines the probability that a random seller re-matches in period τ, call $\gamma_{g\tau}$. The specific set-up costs incurred by manufacturers in *g* depend on $\gamma_g = (\gamma_{g1}, \gamma_{g2})$ only.

Recall finally that bargaining costs are a function of T_g, P_g, and *Mg* only.

Summarizing the above, to find the total surplus implemented in the most efficient Nash equilibrium of a trading efficient mechanism, we just need to know $(M_g, S_g, T_g,$ and $Pg, \gamma_g)$.

Definition: A *game form* governing a sequence of trades between *M* manufacturers and *S* sellers is an extensive form game that allows the players to sort into different mechanisms. After sorting, a seller can only participate in a single mechanism. Manufacturers can participate in several different mechanisms, but only one for each task. If a mechanism requires that players be partitioned into subsets (for example into pairs), this is done as efficiently as possible in period 0. ■

In Section III, we look at the special case of *simple* game forms which are degenerate in the sense that only one mechanism is available. If the mechanism in question is characterized by $(M_g, S_g, T_g, P_g, \gamma_g)$, we will say that the corresponding simple game form is in this *class*.

Definition. A trading efficient simple game form g in the class $(M_g, S_g, T_g, P_g, \gamma_g)$ partitions the players into subsets of $M_g \in Z_+ \cup (0, M]$ manufacturers and $S_g \in Z_+ \cup (0, S]$ sellers. It specifies that members of all subsets play the same trading efficient mechanism. The mechanism has each seller agreeing to $P_g \in Z_+$ parameters covering $T_g \in Z_+$ tasks, and uses the re-matching probabilities $\gamma_g \in [0, 1]^2$. Whenever one of the manufacturers needs a task that does not have a previously agreed upon price, the mechanism is played again. ■

Two examples of trading efficient simple game forms, which will be defined more precisely later, are the *Market* and *Sequential Contracting*. If all T tasks are traded in the Market game form, $(M, S, T, T, 1, 1)$, all M manufacturers make TIOLI offers to S sellers (or use another efficient price determination process), to determine T fees and then consummate all individually rational trades in period 1. This is then repeated in period 2. In the Sequential Contracting game form, $(1, N_m, 1, 1, 0, 0)$, each manufacturer uses TIOLI offers (or another efficient bargaining mechanism) with her own set of N_m sellers, negotiating one fee for one task with each, thus covering N_m tasks in period 1. In period 2 a new set of N_m fees, for different tasks, is negotiated between the same players.

III. ALTERNATIVE SIMPLE GAME FORMS FOR A SEQUENCE OF PURCHASES

We here look at an economy in which all tasks, sellers, and manufacturers are statistically identical such that a single mechanism can govern all trades. We proceed in two steps.

It is first shown that any simple game form is weakly dominated by a member of one of four classes. These classes have arguments that are either at the lowest or highest of what is possible. Intuitively, the reason is that several forces make intermediate solutions unattractive: Gains from trade grow with market size and requires constant re-matching, we need once-and-for-all matching to reap savings on specific set-up costs, and if $M_g = 1$, the concavity of the bargaining costs pushes us all the way towards a single price.

Secondly, in Section III.2, we define one simple game form in each of the four classes and show that these weakly dominate all others within their class. This then provides a justification for focusing attention on the Market, Employment, Sequential Contracting, and Employment with Market Wages. To keep the notation simple, we here assume that $N_m = S/M$ for all m such that all manufacturers have the same number of needs.

III.1. *Characterizing the class of weakly dominant simple game forms.*

The main result of this Section, Proposition 1, is proved in the Appendix through a series of six Lemmas. While the placement in the Appendix is motivated by some of the individual Lemmas being rather trite, it is useful to outline the main flow of the proof. The idea is to start by looking at game forms with $M_g = 1$ and then consider those with $M_g > 1$. As noted in Section II, comparisons within these two classes involve only two components and are thus relatively easy. Lemmas 1 and 2 tell us how to minimize production and bargaining cost when $M_g = 1$, while Lemmas 3, 4 and 5 are about minimizing production and specific set-up costs when $M_g > 1$. These Lemmas allow us to eliminate large classes of game forms as long as we require trading efficiency. Lemma 6 looks at the possibility of sacrificing trading efficiency, but possibly reaping larger savings on bargaining costs and/or specific set-up costs.

In a bit more detail, Lemmas 1 and 3 state that it always is inefficient if the number of sellers differs from the *S/M* per manufacturer that ultimately will be needed. The argument is, of course, that any imbalances will result in lost trades somewhere in the economy. Lemma 2 looks at the tradeoff between the sub-additivity of bargaining costs and the advantages of delays to identify a natural condition under which it is more efficient to negotiate a wage covering an indefinite period, as opposed to a sequence of short term contracts. Lemma 4 looks at markets and finds a weak condition under which a single "large" market is more efficient than several smaller sub-markets. Large markets are then considered in Lemmas 5 and 6. The first of these points out that trading efficiency requires players to be re-matched in between periods, and the next considers the possibility of using different re-matching probabilities in order to trade off trading efficiency against specific set-up costs and bargaining costs.

PROPOSITION 1: *Consider*

(1) $\bar{K} < (1 + \delta)K(1)$, *and*

(2) $\bar{H} > \delta(c^* + u - c)$.

If (1) holds [does not hold], any simple game form with $M_g = 1$ *is weakly dominated by one in (1, S/M, T, 1, 0, 0) [(1, S/M, 1, 1, 0, 0)]. If (2) holds [does not hold], any simple game form with* $M_g > 1$ *is weakly dominated by one in (M, S, T, T, 1, 1), [(M, S, T, T, 1, 0)].*

Proof: See Appendix. ■

The condition *(1)* says that one large bargain now is more efficient than many small bargains in the future and *(2)* says that it is expensive to customize contracts negotiated in the market to local conditions.

We now look at specific game forms in these four classes: The *Market* in *(M, S, T, T, 1, 1), Employment* in *(1, S/M, T, 1, 0, 0), Sequential Contracting* in *(1, S/M, 1, 1, 0, 0),* and *Employment with Market Wages* in *(M, S, T, T, 1, 0).*

III.2. *Market, Employment, Employment with Market Wages, and Sequential Contracting as weakly dominant in their classes.*

We here define the four simple game forms and then show that they weakly dominate all others of the same class. To highlight the differences between the four game forms, when defining each, we put in bold type the stages it adds to the sequence of informational events.

Definition. The *Market game form* in the class *(M, S, T, T, 1, 1),* prescribes the following extensive form game between *M* manufacturers and *S* sellers:

In period *0*:

Sellers' areas of expertise $t^*(s)$ are realized along with manufacturer needs for the period, $\boldsymbol{n}^{m0}$. Sellers and manufacturers are matched accordingly.

In each period $\tau = 1, 2$:

τ.1. All manufacturers' needs $\boldsymbol{n}^{m\tau}$ are realized.

τ.2. **All manufacturers make TIOLI offers to find the *fees*** $\boldsymbol{f_\tau} = (f_{1\tau}, f_{2\tau}, \ldots f_{T\tau})$.

τ.3. **For all** t**, manufacturers needing** t **pay** u **and are matched with sellers willing to work for** $f_{t\tau}$**.**

τ.4. If trade is agreed, sellers perform their tasks and payments are made. ■

Remark. In equilibrium, sellers are only active in the area of their expertise. So one could also describe the mechanism as being in the class *(M, S, 1, 1, 1, 1).* ■

As shown by the following Lemma, the fees will be the same in every period.

LEMMA 7: *Market fees are* $f_{t\tau} = c^*$ *for all* τ*.*

Proof: The least efficient expert will have effort costs c^* every period, and the fees will equal costs since the sellers are the long side of the market. Fees will be the same in each period, since that the distributions of expertise and costs are constant over time. ■

PROPOSITION 2: *Given (2), the Market gives weakly more surplus than any other simple game form in the class (M, S, T, T, 1, 1).*

Proof: Total two-period costs under the Market game form are $(1 + \delta)(c^* + u)$. No game form can implement lower production costs. By Lemmas 3 - 6, if *(2)* holds, no trading efficient game form with $M_g > 1$ can economize on u without incurring larger costs elsewhere. ■

Definition. The *Employment game form* in the class *(1, S/M, T, 1, 0, 0)*, prescribes the following extensive form game between *1* manufacturer and *S/M* sellers.

In period *0*:

Sellers' areas of expertise $t^*(s)$ are realized along with manufacturer needs for the period, $\boldsymbol{n}^{m0}$. Sellers and manufacturers are matched accordingly.

0. 1. **Manufacturers make sellers TIOLI offers to find a wage w_{sm}, while incurring bargaining costs $\bar{K}$ per seller.**

In each period $\tau = 1, 2$:

$\tau.1$. Manufacturer's needs $\boldsymbol{n}^{m\tau}$ are realized.

τ.2. **Each manufacturer distributes her needs across the *S/M* employees and asks each employee to meet one need. The employee can agree or not. Either party can dissolve the match at any time. If so, the employee has zero payoffs and the manufacturer has one unmet need in all future periods.**

τ.3. If trade is agreed, employees perform their tasks and payments are made.■

Given this, we have

LEMMA 8: *Wages are* $w_{sm} = c$.

Proof: Trades are advantageous for the employee if $c \leq w_{sm}$. Manufacturers will thus make the TIOLI offer c. ■

PROPOSITION 3: *Given (1), no simple game form in the class (1, S/M, T, 1, 0, 0) gives more surplus than Employment*.

Proof: Expected per-seller per-period cost under Employment is $c + \overline{K}/(1+\delta)$. All game forms of this class have to incur $\overline{K}/(1+\delta)$ and none can have lower expected production costs than c.

Definition. The *Sequential Contracting game form* in the class *(1, S/M, 1, 1, 0, 0),* prescribes the following extensive form game between *1* manufacturer and *S/M* sellers.

In period *0*:

Sellers' areas of expertise $t^*(s)$ are realized along with manufacturer needs for the period, $\boldsymbol{n}^{m0}$. Sellers and manufacturers are matched accordingly.

In each period $\tau = 1, 2$:

τ.1. Manufacturer needs $\boldsymbol{n}^{m\tau}$ are realized.

τ.2. **Manufacturer distributes her needs across sellers and makes each of her contractors TIOLI offers, while incurring bargaining costs** *K(1).*

τ.3. If trade is agreed, contractors perform their tasks, and payments are made.■

PROPOSITION 4: *If (1) does not hold, no simple game form in the class (1, S/M, S/M, 1, 0, 0) gives more surplus than Sequential Contracting.*

Proof: Expected per-seller per-period costs under the Sequential Contracting game form is *c +K(1)*. All game forms of this class have to incur *K(1),* and none can have lower production costs than *c.* ■

Definition. The *Employment with Market Wages game form* in the class *(M, S, T, T, 1, 0),* prescribes the following extensive form game between *M* manufacturers and *S* sellers:

In period *0*:

Sellers' areas of expertise *t*(s)* are realized along with manufacturer needs for the period, $\boldsymbol{n}^{m0}$. Sellers and manufacturers are matched accordingly.

1.1. All manufacturers' needs $\boldsymbol{n}^{m1}$ are realized.

1.2. **All manufacturers make TIOLI offers to find the *wages*** w_j.

1.3. **Sellers are matched with manufacturers according to needs and expertise. The contracts are customized to the match and manufacturers incur** $\overline{H}$.

1.4. **For all** *t*, **each matched seller-manufacturer pair trades at** w_j **iff both agree. Either party can dissolve the match at any time. If so, the employee has zero payoffs and the manufacturer has one unmet need in all future periods.**

1.5. If trade is agreed, sellers perform their tasks, payments are made, and output is traded.

2.1. All manufacturers' needs $\boldsymbol{n^{m2}}$ are realized.

2.2. **For all** t**, each matched seller-manufacturer pair trades at** w_j **iff both agree.**

2.3. If trade is agreed, sellers perform their tasks and payments are made. ■

PROPOSITION 5: *If (2) does not hold, Employment with Market Wages gives weakly more surplus than any other simple game form in the class (M, S, T, T, 1, 0).*

Proof: Total two-period costs under the Employment with Market Wages game form is $c^* + u + \bar{H} + \delta c$. No game form in this class can implement lower production costs. By Lemmas 3- 6, if *(2)* does not hold, no game form can economize on $u + \bar{H}$ without incurring larger costs elsewhere.■

If we assume that v is so large that any of these four game forms create value, the most efficient simple game form depends on the five parameters: $c^* + u - c$, $\bar{K}$, $\bar{H}$, $K(1)$, and δ.

THEOREM 1: *Consider*

$$(3) \qquad c^* + u - c < \bar{K}/(1+\delta),$$

$$(4) \qquad c^* + u - c < K(1),$$

$$(5) \qquad c^* + u - c < \bar{K} - \bar{H}, \text{ and}$$

$$(6) \qquad c^* + u - c < (1+\delta)K(1) - \bar{H}.$$

If (1), (2), and (3) hold, any simple game form is weakly dominated by the Market. If (1) and (2) hold, but (3) does not, any game form is weakly dominated by Employment.

If (2) and (4) hold, but (1) does not, any simple game form is weakly dominated by the Market. If (2) holds, but (1) and (4) do not, any simple game form is weakly dominated by Sequential Contracting.

If (1) and (5) holds, but (2) does not, any simple game form is weakly dominated by Employment with Market Wages. If (1) holds but (2) and (5) do not any simple game form is weakly dominated by Employment.

If (6) holds, but (1) and (2) do not, any simple game form is weakly dominated by Employment with Market Wages. If neither (1), (2), nor (6), holds, any simple game form is weakly dominated by Sequential Contracting.

Proof: Follows directly from Propositions 1, 2, 3, 4, and 5. ■

Consistent with intuition and casual observation, the Market is better when the efficiency gap between experts and laymen is wider ($c^* - c$), when the costs of re-matching are smaller (u)[4], when trade is less frequent (δ), and when bargaining costs are larger. Employment is better than Sequential Contracting when trade is frequent, and Employment with Market Wages is better when jobs are standardized ($\overline{H}$).

IV. THE MIX OF MARKET AND EMPLOYMENT FOR DIFFERENT TASKS

We first generalize the model by introducing differences between tasks. This lets us analyze cases in which different tasks are traded in different mechanisms. We assume that *(1)* and *(2)* hold and thus focus on the Market versus Employment choice. So some sellers elect to be *employees*, while others opt to sell their services as *professionals* in the Market. To keep the

[4] *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.

derivations uncluttered, we look at task heterogeneity on a dimension-by-dimension basis, allowing one dimension to vary with t in each subsection.

We use $\mathcal{T}_e$ for the set of tasks governed by Employment, such that the set $\mathcal{T}\backslash\mathcal{T}_e$ is sourced in the Market. Similarly, $\mathcal{S}_e$ is the set of sellers working as employees, while the rest are professionals. The optimal values of these will be $\mathcal{T}_e$* and $\mathcal{S}_e$*.

Definition. The *game form with both Markets and Employment,* prescribes the following extensive form game between M manufacturers and S sellers.

In period *0:*

0.1 .Sellers' areas of expertise $t^*(s)$ are realized along with manufacturer needs for the period, $\boldsymbol{n}^{m0}$. Sellers and manufacturers are matched accordingly.

***0. 2*. Each seller chooses whether to be a professional or an employee.**

***0. 3*. Manufacturers decide which tasks to source from employees and which to get in the Market.**

***0. 4.* Each manufacturer makes TIOLI offers to each of her employees, incurring bargaining costs $K(|\mathcal{T}_e|)$ for each.**

In each period $\tau = 1, 2$:

$\tau.1$. Manufacturer needs $\boldsymbol{n}^{m\tau}$ are realized.

$\tau.2$. **Each manufacturer distributes her needs $t \in \mathcal{T}_e$, across her employees and asks each to meet zero, one, or more of these needs. The employee can agree or not. Either party can dissolve the match at any time. If so, the employee has zero payoffs and the manufacturer has one unmet need in all future periods.**

τ.3. **For each t** $\in \mathscr{T}\backslash\mathscr{T}_e$, **all manufacturers needing** t **make TIOLI offers to find a** $|\mathscr{T}\backslash\mathscr{T}_e|$ **vector of fees** $\boldsymbol{f_{t\tau}}$

τ.4. **For all** $t \in \mathscr{T}\backslash\mathscr{T}_e$, **professionals bidding less than (or equal to)** $f_{t\tau}$ **are matched with manufacturers needing** t. **The manufacturers incur** u **per professional.**

τ.5. **For all** $t \in \mathscr{T}\backslash\mathscr{T}_e$, **each matched professional-manufacturer pair can agree to trade at** $f_{t\tau}$**. If one or both disagree, they have a new opportunity to trade in the next period.**

τ .6 If trade is agreed, sellers perform their tasks, and payments are made. ■

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

(i) All manufacturers have all needed tasks performed.

(ii) All sellers weakly prefer the 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 professionals weakly prefer the task to which they are allocated.■

IV.1 *The Market is, ceteris paribus, used for tasks with larger performance differences between experts and laymen.*

In this subsection, we maintain that $\int_m n^{mt\tau} = N_t$ for all (t, τ), implying that demand for all tasks is the same, and that manufacturers are ex ante identical, such that $N_m = N_{m'}$ for all m and that $n_{mt} = n_{m't} = n_t$ for all m, m', t. We are here interested in the case in which $c_t{}^* \neq c_{t'}{}^*$ for $t \neq t'$ such that the costs of experts for different tasks are different.

PROPOSITION 6: *Professionals perform all tasks in which experts' cost advantage over laymen is higher than that given by (3), while all other tasks are performed by employees.*

Proof: Experts at t will prefer being professionals rather than employees if:

$$(7) \qquad f_t - c_t^* \geq w - c = 0$$

So the supply of professionals, $x(f_t,)$, is

$$(8) \qquad x_t(f_t,) = S/T \qquad \text{if } f_t \geq c_t^* \text{ and } 0 \text{ otherwise}$$

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

$$(9) \qquad y_t(f_t,) = S/T \qquad \text{if } f_t + u \leq c + K(\,|\mathcal{T}_e|\,)/(1+\delta) \text{ and } 0 \text{ otherwise.}$$

Depending on the relationship between the functions *(8)* and *(9)*, there are two classes of equilibria, reflecting whether *(3)* holds or not: If $c_t^* + u - c \leq \bar{K}/(1+\delta)$, t would be performed entirely by professionals, while if $c_t^* + u - c > \bar{K}/(1+\delta)$, 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.) ■

IV. 2. *The Market is, ceteris paribus, used for tasks with lower set-up costs and less change.*

Reasoning again from *(3)*, we state a parallel result without proof.

PROPOSITION 7: *Tasks with lower specific set-up costs (less frequent change) are performed by professionals, while those with higher specific set-up costs (more frequent change) are performed by employees.*

To the extent that the specific set-up costs simply are due to transportation, the intuition is that a market for professionals 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 set-up costs are more substantial, such as those incurred in the process of learning how to serve a specific manufacturer. If δ 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 specific set-up 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 result about specific set-up costs is extremely intuitive, but the effect of the frequency of change is perhaps less so. However, Novak and Wernerfelt (2012) find strong support for it in a large study of the automobile industry.

While the model analyzed so far had heterogeneous tasks, we can prove parallel results for heterogeneous sellers.

V. THE CHOICE OF MECHANISMS BY DIFFERENT SELLERS

V.1 .*The Market is, ceteris paribus, used by the more efficient sellers.*

Suppose that, for all tasks, some experts have costs $\underline{c}^*$ while others have costs $\underline{c}^*+1$. Assuming that *(1)* and *(2)* hold even for $\underline{c}^*+1$, we again focus on the Market versus Employment choice.

PROPOSITION 8: *If (3) holds for* $c^*= \underline{c}^*$, *but not for* $c^* = \underline{c}^* + 1$, *the more efficient sellers will work as professionals and less efficient sellers will become employees.*

Proof. As in the proof of Proposition 6, the demand for professionals will be a one-step function, but the supply will now be a two-step function. The premise in the Proposition is that they intersect on the middle step. ■

Remark. Similar results obtain elsewhere in the parameter space. For example, if neither *(1)* nor *(2)* holds, either Sequential Contracting or Employment with Market Wages is weakly dominant and the critical condition is *(6).* In this case, the most efficient sellers will become Employees with Market Wages (because this allows them to work as experts in period *1*). ■

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

<u>V.2 *The Market is, ceteris paribus, used by more efficient sellers for tasks with less demand.*</u>

In this subsection, we assume that demand, $\int_m N_m n_t$, differs between tasks and that expert costs are drawn IID from a uniform distribution with support $[\underline{c}^*, \underline{c}^* + 1]$.

PROPOSITION 9: *(a) Among the tasks for which* $\int_m N_m n_t \leq S/T$*; if*

$$(10) \qquad \underline{c}^* + \int_m N_m n_t T/S + u \leq c + \bar{K}/(1+\delta),$$

all needs are met by professionals. If (10) does not hold, but

$$(11) \qquad \underline{c}^* + u \leq c + \bar{K}/(1+\delta),$$

needs are met by a mixture of professionals and employees. If (11) does not hold, all needs are met by employees.

(b) Among the tasks for which $\int_m N_m n_t > S/T$*; if (11) holds, needs are met by a mixture of professionals and employees, and if (11) does not hold, all needs are met by employees.*

Proof : See Appendix

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

VI. USE OF DIFFERENT MECHANISMS FOR DIFFERENTLY SIZED NEEDS

While we, in Sections IV and V, looked at how the use of mechanisms differs between tasks and sellers, we now generalize the model in a different direction to ask how mechanisms differ between manufacturers of different sizes. We assume that manufacturers have some *stable needs* in the sense that they are sure to need certain tasks done in every period, perhaps even by several sellers. To model this, we define $N_{mt} \in Z_+ \cup \{0\}, t \in \mathcal{T}$, as the number of sellers m needs to perform t in every period. It is convenient, but not necessary, to assume that $\sum_t N_{mt} = S/M - 1$ for all m. So all manufacturers need one random tasks performed and n_{mt} is still the corresponding parameter of the multinomial distribution. This framework allows us to analyze the use of specialized employees as substitutes for professionals.

We maintain that all tasks have the same uniform distribution of costs with support $[\underline{c}^*, \underline{c}^* + 1]$ and that $\int_m n_{mt} = S/T$ for all t, such that total needs for each task are the same.[5]

Definition: A *specialist* employee performs tasks for a single manufacturer in return for a once-and-for-all negotiated wage, but concentrates all of his work on one task.[6] ■

The extensive form is the same as in Section IV, except that sellers now decide between careers as professionals, specialists, or employees, while manufacturers decide which tasks to acquire from each of these three types of sellers.

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[5] 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 professionals only. (Since no manufacturer will have large enough needs to justify hiring a specialist.)
[6] If we allow N_{mt} to be continuous, some employees will be fractionally specialized and paid accordingly.

Definition. An *equilibrium with large manufacturers* is an allocation of sellers to mechanisms, professionals to tasks, and employees to manufacturers, such that

(i) All manufacturers have all needed tasks performed.

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

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

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

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

We will describe an efficient outcome and show in the Appendix that it is an equilibrium. Consider the task *t* and the seller *s*. The total two-period costs if *s* is a specialist, an employee, and a professional are $(1 + \delta)c_{st}^* + \bar{K}$, $(1 + \delta)c + \bar{K}$, and $(1 + \delta)(c_{st}^* + u)$, respectively. The social return to lower c_{st}^* is the same for specialists and professionals, but since $(1 + \delta)u > \bar{K}$, the former create more surplus. As the stronger types thus can offer manufacturers more, the $\int_m N_{mt} = (S - M)/T$ most efficient sellers will work as specialists on *t*. The next most efficient group will then be professionals, while employees will come last.

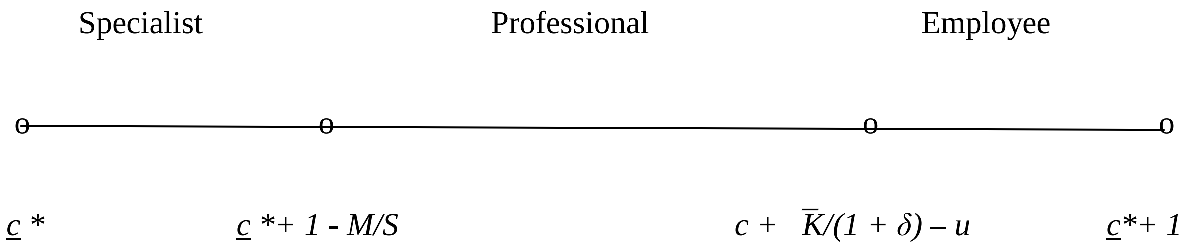
Out of the *S/T* sellers who are experts at a task *t*, the $(S - M)/T$ most efficient will thus work as specialists and the least efficient among them will have costs $c_{st}^* = \underline{c}^* + 1 - M/S$. Moving further down the efficiency order, let $c^{\#} \in [\underline{c}^* + 1 - M/S, \underline{c}^* + 1]$ be the cost of the least efficient professional. This seller is as efficient as an employee when the analog of *(3)* holds with equality such that $c^{\#} + u - c = \bar{K}/(1 + \delta)$. So both professionals and employees will be hired if

$$(12) \qquad \underline{c}^* + 1 - M/S < c + \bar{K}/(1 + \delta) - u < \underline{c}^* + 1$$

This is illustrated in Figure 2 below.

Figure 2

Mechanisms for Different Levels of Efficiency



More completely, for this model we have

THEOREM 2: *If manufacturers are large, tasks have identical cost distributions, and total demand for each task is the same, there exists an equilibrium in which*

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

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

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

(d) *in order of decreasing efficiency, sellers become specialists, professionals, and employees.*

Proof: See Appendix[7]

This then explains why larger firms employ specialized labor, such as lawyers and plumbers, which smaller firms hire on a case-by-case basis. Consistent with many recent empirical findings, the theory also predicts that larger firms outsource less and produce more efficiently (Hortacsu and Syverson, 2007; 2009).

VII. TRADE AND DISTANCE

We can model tariffs and geographical distances in the workhorse model by letting the specific set-up 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 $t \in \mathscr{T}'$ together with $M|\mathscr{T}'|/T$ manufacturers and another with all the other agents (and thus all sellers who are experts in tasks $t \in \mathscr{T} \backslash \mathscr{T}'$). Suppose further that the specific set-up 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 professionals while the rest will be employees. However, if the clusters are merged, all sellers will become professionals.

FINDING 1: *If barriers between initially unbalanced clusters are reduced, more sellers become professionals 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.

VIII. THE EQUILIBRIUM SCOPE OF MANUFACTURERS

[7] 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.

While manufacturers' needs so far have been assumed to be exogenous, Theorem 2 suggests that they would have incentives to focus their production in order to hire specialists instead of employees. We now look at this possibility.

VIII.1. *Focus when production possibilities exceed available labor.*

To make scope decisions interesting, we now assume that economy-wide production possibilities exceed the supply of labor. In fact, to keep the analysis simple, we go a bit further and assume that the stable needs by themselves exceed the available labor supply such that $\int_m \sum_t N_{mt} > S$. Each manufacturer than has to decide which of her needs to meet. Specifically, we will define $\mathcal{N}_{mt} \leq N_{mt}$, $t = 1, 2, .. \ t, .. T$ as the *active needs* of manufacturer *m*, the fraction of her needs she decides to meet. To look at this we modify the extensive form from Section IV such that manufacturers initially decide which needs to activate. The definition of equilibrium is similarly extended.

Since all output is identical and sold in the same market, manufacturers face the same price and will first aim to activate their stable needs (, since this allows them to hire specialists). Given our assumption about the sum of needs, $\int_m \sum_t \mathcal{N}_{mt} = S$ and the wages of specialists, w_t, are bid up to the zero profit level. All sellers will be hired as specialists, and since $\underline{c}^* + 1$ is the cost of the least efficient specialists,

$$w_t = v - \overline{K}/(1 + \delta), \text{ where } \underline{c}^* + 1 \leq v - \overline{K}/(1 + \delta) . \tag{13}$$

So we have

FINDING 2: *Suppose that total demand for each task is the same, and that stable production possibilities exceed available labor. Then, in all equlibria, manufacturers focus their activities on stable production possibilities and hire specialists only.*

This is 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 specialists. This in turn raises the question about the ability these employees to bargain for some or all of the gains (just as the equilibrium described above has zero profits). The more modern, and more influential, versions of the argument are therefore based on excess capacity of groups of employees. This is more appealing, both because it is harder to imagine joint wage bargaining by a large group and because of the sense that one needs larger forces to explain the size of larger firms.

While it is gratifying that Finding 2 is consistent with practitioner perspectives, it obviously paints too stark a picture. In reality, we also observe professionals, less specialized employees, and contractors, presumably because complementarities between tasks make complete focus unattractive.

VIII. 2. *Mergers and limits to scale.*

The foregoing discussion leads naturally to questions about the optimal size of the firm. As the model stands now, optimal size is the result of a very simple tradeoff. If two manufacturers merge, one entrepreneur will become an employee and thus needs to negotiate an employment contract, incurring a one-time cost $\bar{K}$ in the process. On the other hand, the merged unit may be able to employ more specialists and the advantages of that could outweigh the bargaining costs. So the optimal size is found when it no longer is possible to find a partner with sufficiently complementary needs.

The above explanation parallels that made by the property rights theory, according to which the cost of a merger is a reduction in the incentives of one of the former entrepreneurs. Unfortunately, both arguments strain credibility when applied to larger firms (Holmstrom, 1999), and it seems clear that a new component has to be added to the theory in order to overcome this.

We could build a theory of optimal firm scope by re-interpreting expertise as a result of specialization, rather than pure talent. Suppose that we can classify manufacturing activities into a finite set I of "industries" and index tasks by the industry in which they are performed: (t, i), $i \in I$. If industries are sufficiently different that gains from specialization do not transfer, we could extend the workhorse model with the following extreme assumption: If s is an expert at t, he can perform any task in (t, i), for any $i \in I$, at cost c^*, as long as he only works in (t, i); whereas his costs are c if he performs t in more than one industry. This assumption would result in costs decreasing with volume within an industry, but increasing with the extent of inter-industry diversification, in line with empirical results (Hortacsu and Syverson, 2007; 2009; Montgomery and Wernerfelt, 1988; Wernerfelt and Montgomery, 1988).

There are, of course, many other possible ways to adapt the model to better speak to larger firms. For example, we could assume that manufacturers have to invest in the information required to identify needed tasks, that a merger causes some of the information of the manufacturer-turned-employee to be lost, or that manufacturers have to spend some resources monitoring employees. All of these will naturally lead to decreasing returns to scale and could also explain the use of multi-layered hierarchies.

IX. CONCLUSION

We have characterized equilibrium use of markets, employment, sequential contracting, and employment with market wages, as well as the tasks, sellers, and manufacturers for which each is most efficient. Many of the predictions are easily testable.

In terms of future research, the workhorse model from Section III is deliberately very simple and can easily be extended in any number of directions. One could, for example, look at multiple categories of needs, complementarities between needs, broader areas of expertise, investments in physical assets, incomplete information, endogenous labor supply, and different divisions of gains from trade.[8] As discussed in Section VIII.2, it is particularly important to extend the model to better fit larger manufacturers.

A less direct extension would be to look at the economy's ability to absorb various shocks. The use of the employee/specialist mechanisms is main novelty of the model and the fixed up front costs 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 professionals or 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.

[8] It is also tempting to solve a general equilibrium version of the model. However, doing this in an earlier version added little insight.

APPENDIX: PROOFS

Proof of Proposition 1

As mentioned in the main text, we prove the Proposition through a sequence of six Lemmas. Conditions *(A1)* and *(A2)* are used in the main text as *(1)* and *(2)*.

LEMMA 1: *Among simple game forms with $M_g = 1$, those with the highest overall efficiency have $S_g = S/M$. The only logically feasible re-matching probability is $(\gamma_{g1}, \gamma_{g2}) = (0, 0)$.*

Proof: Recall first that each manufacturer needs exactly S/M tasks per period, that sellers cannot participate in more than one mechanism in a single period, and that there are a total of S sellers and M manufacturers. For every group playing a mechanism with $M_g = 1$ and $S_g \neq S/M$, there is thus one or more other groups playing a mechanism too few or too many sellers. There are no advantages of this, but a loss is created by game forms with $S_g \neq S/M$. The problem is that some of the S_g sellers will not be able to work and that some other manufacturers will not be able to produce as much as they could. ■

LEMMA 2: *Among simple game forms with $M_g = 1$and $S_g = S/M$, those with $P_g = 1$ and $T_g = T$ will have the highest overall efficiency if*

$$(A1) \qquad \overline{K} < (1 + \delta)K(1).$$

If (A1) does not hold, those with have highest overall efficiency have $P_g = 1$ and $T_g = 1$.

Proof: The number of times two players bargain is independent of P_g. The buyer incurs costs $P_g K(T_g)$ every time and the costs are minimized for $P_g = 1$.

Once T_g is sufficiently large, bargaining costs do not grow with larger T_g and it is most efficient to use $T_g = T$ thus eliminating all needs for future bargaining. On the other hand, if δ is very small, it is attractive to set $T_g = 1$ and postpone as much bargaining as possible. Since T is uncountable, the probability that the manufacturer will need the same task twice in finite time is vanishingly small. So any intermediate value of T_g will still necessitate bargaining in every period and yet entail larger bargaining costs than $T_g = 1$. ■

LEMMA 3: *Among simple game forms with $M_g > 1$, those with the highest overall efficiency have $S_g = M_g S/M$.*

Proof: By the same argument as that used to prove Lemma 1. ■

LEMMA 4: *(a) Among simple game forms with $M_g > 1$ and $S_g = M_g S/M$, those with the weakly highest overall efficiency have $M_g = M$.*

(b) Among simple game forms with $M_g = M$ and $S_g = S$, those with the highest overall efficiency have $T_g = T$.

Proof: (a) As S_g grows, so does the chance of one of the sellers being an expert in a task needed by one of the manufacturers in the mechanism. For $S_g = S$, the probability is one, and all tasks can be performed by experts at costs $c^* + u$. For finite S_g, there is essentially no chance that an included seller is an expert in a needed task. The best alternative is for the players to save u by having the task performed by the most recent seller serving the manufacturer in question, in which case the cost is $K(1) + c$. So $S_g = S$ if $K(1) + c \geq c^* + u$, and if this inequality does not hold, $M_g = 1$.

(b) For larger values of T_g, there is a greater chance of being able to take advantage of the expertise of the participating sellers. ■

LEMMA 5: *Among trading efficient simple game forms with $M_g = M$, $S_g = S$, and $T_g = T$, those with $P_g = T$ and re-matching probabilities $(\gamma_{g1}, \gamma_{g2}) = (1, 1)$ are weakly most efficient.*

Proof: There is no loss from agreeing on separate prices for each task and unless players rematch every period, trading efficiency cannot be achieved.■

Noting that Lemma 5 compares against trading efficient game forms only, this still leaves open the possibility of sacrificing trading efficiency in order to save more on bargaining costs or specific set-up costs. This requires the use of another re-matching probability than that used to get trading efficiency.

LEMMA 6: *Among simple game forms with $M_g = M$, $S_g = S$, $T_g = T$, the re-matching probability (1, 1) weakly dominates (1, 0) iff*

$$\text{(A2)} \qquad \bar{H} > \delta(c^* + u - c).$$

The most efficient of (1, 1) and (1, 0) weakly dominates all others.

Proof: Since all manufacturers are matched with laymen sellers at the start of period *1*, there is no need to consider intermediate values of γ. The only two values that can be optimal are *1* and *0*. Noting that $(\gamma_{g1}, \gamma_{g2}) = (0, 0)$ implies that the game form can be written with $M_g = 1$, we consider $(0, 1)$ and $(1, 0)$ only. Total costs for periods 1 and 2 for simple game forms in the classes $(M, S, T, P_g, 0, 1)$, $(M, S, T, P_g, 1, 0)$, and $(M, S, T, P_g, 1, 1)$ are $K(1) + c + \delta(u + c^*)$, $u + \overline{H} + c^* + \delta c$, and $(1 + \delta)(u + c^*)$, respectively. So $(M, S, T, P_g, 0, 1)$ dominates $(M, S, T, P_g, 1, 1)$ iff $K(1) + c < c^* + u$, but in that case $(1, S/M, 1, 1, 0, 0)$ is weakly better. On the other hand, $(M, S, T, P_g, 1, 0)$ is more efficient than $(M, S, T, P_g, 1, 1)$ iff $(A2)$ holds.■

Proposition 1 follows directly from Lemmas 1 - 6. ■

Proof of Proposition 9

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

$$(A3) \qquad f_t - \underline{c}^* - \int_m N_m n_t T/S \geq w - c.$$

As $w = c$ and manufacturers will require that $f_t + u \leq w + \overline{K}/(1 + \delta)$, the task t will be supplied entirely by professionals if the cost of hiring the least efficient professional is larger than that of hiring an employee, or if

$$(A4) \qquad \underline{c}^* + \int_m N_m n_t T/S + u \leq c + \overline{K}/(1 + \delta).$$

If $(A4)$ does not hold, the best experts will still prefer working as professionals as long as

$$(A5) \qquad \underline{c}^* + u < c + \overline{K}/(1 + \delta).$$

However, in this case the rest of the tasks would be performed by employees. If $(A5)$ does not hold, all tasks are performed by employees.

The tasks for which $\int_m N_m n_t > S/T$ cannot be fully supplied by experts and the fee f_t would be bid up to $c + \overline{K}/(1 + \delta) - u$. Some experts will prefer to work as professionals as long as $(A5)$ holds and all will prefer to do so if

$$(A6) \qquad \underline{c}^* + 1 \leq c + \overline{K}/(1 + \delta) - u.■$$

Proof of Theorem 2

We find a set of wages and fees that implement the equilibrium. 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, while using f_t as the fee of a professional, and w as the negotiated salary of an employee. The postulated equilibrium is implemented by prices meeting following IR- IC conditions*:*

The marginal specialist is indifferent between that and being a professional if

$$(A7) \qquad w_t = f_t,$$

and the marginal professional is indifferent between that and being an employee if

$$(A8) \qquad f_t - c^{\#} = w - c.$$

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

$$(A9) \qquad w_t + \bar{K}/(1 + \delta) \leq f_t + u$$

and they are indifferent between professionals and employees for jobs with small n_{mt} if

$$(A10) \qquad f_t + u = w + \bar{K}/(1 + \delta)$$

The IR constraints for the three groups of sellers are

$$(A11) \qquad w_t \geq \underline{c}* + 1 - M/S,$$

$$(A12) \qquad f_t \geq c^{\#}, \text{ and}$$

$$(A13) \qquad w \geq c.$$

Finally, the IR constraints for the manufacturers are

$$(A14) \qquad v \geq w_t + \bar{K}/(1 + \delta)$$

$$(A15) \qquad v \geq f_t + u, \text{ and}$$

$$(A16) \qquad v \geq w + \bar{K}/(1 + \delta).$$

Since *(A11) – (A16)* can be met simply by raising the level of wages, fees, and prices, we focus on *(A7) – (A10).* The first two conditions are satisfied by $f_t = w_t = c^{\#}$ and $w = c.$

Since $u > \bar{K}/(1 + \delta)$, these also insure that *(A9)* is met and they meet *(A10)* for

$c^{\#} = c + \bar{K}/(1 + \delta) - u$. So the proposed fees and wages implement an equilibrium. ■

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