Agglomeration, Opportunism, and the Organization of Production

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Abstract

Recent economic analysis of outsourcing has emphasized its international dimension. In contrast, this paper focuses on local outsourcing. The paper specifies and solves a model where the organization of production (vertically integrated or not) and the location of production (agglomerated or not) are jointly determined. The paper shows that agglomeration reduces opportunism, a thick market effect, and so serves as a substitute for integration. This force will lead firms to agglomerate. The paper also shows that the normative properties of equilibrium with local outsourcing are not as clear cut as for international outsourcing. Since local agglomeration is achieved at the cost of congestion, local markets may be too thick, which would not be the case for an increase in the thickness of a world market. Finally, the many changes in economic and social circumstance that have been labeled "globalization" do not only impact vertically integrated firms. They also impact cities and industry clusters to the extent that agglomeration is a substitute for vertical integration.

Keywords: Agglomeration, vertical integration, transactions cost, opportunism

I. Introduction

Some of the best papers on outsourcing begin with discussions of Barbie dolls (Feenstra [14], Grossman-Helpman [19]). Barbie's contribution to the understanding of outsourcing is as follows: the doll is produced using plastic and hair from Taiwan and Japan and assembled in Indonesia and Malaysia. The molds are made in the U.S. Barbie is clothed by Chinese, and decorated in the U.S. In sum, Barbie is a small plastic icon of international outsourcing. There are many other examples of outsourcing that are not much different from Barbie, including cars. The bottom line of all this is that outsourcing has an important international dimension. In fact, the term "outsourcing" has been used as a synonym for international vertical disintegration.[1]

While it is undeniable that the international outsourcing of inputs is a phenomenon of crucial importance, it is not true that outsourcing is inherently global. There are many instances where local outsourcing of inputs is extensive. A particularly striking instance is business services. Schwartz [38] makes a compelling case that firms disproportionately purchase business services from within their own city. Looking at central city companies and across all services, 48.3% of service outsourcing was within a city. This proportion is much larger for some services: legal counsel (72.5%), major bank (54.2%), business insurance brokerage (60.9%), and auditing (79.1%). Looking at demanders in New York, Los Angeles, Chicago, and San Francisco, the figures are larger: all services (65.2%), legal counsel (87.0%), major bank (75.0%), insurance brokerage (74.4%), and auditing (86.9%). (Schwartz [38], p. 293). The figures are slightly lower but still high for companies located in the suburbs: all services (49.5%), legal counsel (69.3%), major bank (52.2%), business insurance brokerage (54.3%), and auditing (70.7%) (Schwartz [38], p. 293). Historical evidence of local outsourcing can be

[1] Feenstra and Hanson [15, p. 240]: "...outsourcing, by which we mean the import of intermediate inputs by domestic firms."

found in Chapman and Ashton [4], who show that there exists a positive relationship between agglomeration and disintegrated production in the British cotton textile industry. More recent evidence can be found in Scott [36, 37], who considers the Los Angeles garment, printed circuit, and jewelry industries.

Outsourcing has been a topic of interest in several different areas of economics. The urban economic analysis of outsourcing begins with Marshall [29]. His treatment is technological: when there are scale economies in the provision of nontradable intermediate inputs, there is an increasing return associated with spatial agglomeration. In this literature, Goldstein and Gronberg [18] focus on cost complementarities and input sharing, while Helsley and Strange [24] show that input sharing in a probabilistic sense facilitates innovation. Duranton and Puga [12] present a model where a new product requires a different kind of input sharing than does a mature product.

Outsourcing is also considered in the literature on the theory of the firm. Coase [5] is seminal. This is a large literature and we will not attempt to review it here. See Williamson [40], Holmstrom and Tirole [25], and Hart [22] for surveys. The heart of the literature is the determination of the boundary of a firm. The transactions cost theory of the firm holds that opportunism and relationship specific investment are central to this determination. Opportunism arises when contracts are incomplete. In this case, it may be possible for one party to an ongoing relationship to "hold-up" the other for favorable terms. The possibility of this hold-up leads to an inefficiently low level of relationship specific investment. This in turn encourages vertical integration, since hold-up is less likely to occur when both parties to a relationship are part of a single firm. One kind of investment that is in peril of hold-up is site-specific investment. For example, when the costs of moving inputs are large, an investment in input production is useful only to nearby demanders. Joskow [28] shows that site-specificity leads to the vertical integration of co-located coal-burning electricity generating plants and coal mines. Although this suggests that transactions costs in general and opportunism in particular may be important forces leading to agglomeration, nearly all work on the economics of agglomeration is in the spirit of Marshall's technological microfoundations and does not consider either transactions costs or opportunism. The paper that provides the most complete treatment of the link between transactions costs and agglomeration is Rotemberg and Saloner [35]. It considers worker incentives to acquire industry specific training when firms cannot commit to reward their investments. Because the paper focuses on labor markets, however, it cannot consider the choice between integrated and disintegrated production.[2]

The international economics literature has considered outsourcing as well. Three recent papers (Grossman-Helpman [19,20] and McLaren [31]) have added to the theory of the firm literature by providing models of transactions costs and the boundaries of the firm in an industry equilibrium. These papers have established that market thickness effects can lead to multiple equilibria in organizational form, vertically integrated or not. McLaren has also shown that decreases in the costs of trade, by increasing market thickness, can lead to greater outsourcing. Since market thickness is an industry level public good, equilibrium is inefficient, with the amount of outsourcing being below the efficient level. This analysis is conducted at the level of the nation or the world, and it thus misses some important aspects of local outsourcing.

This paper contributes to all three of these literatures. The analysis is carried out in the context of a model with two types of agents, input suppliers and final goods producers (input demanders). Inputs are specialized and contracts are incomplete. In this setting, in demanders have an incentive to opportunistically exploit suppliers' relationship-specific investments. The alternative to outsourced input supply is internal production, which we assume to be more costly than external production. In this model, the organization of production (vertically integrated or not) and the location of production

[2] Dudey [10,11] models retail concentration as a response to a similar kind of opportunism, but for obvious reasons it does not consider the possibility of vertical integration.

(agglomerated or not) are jointly determined. In extensions of the model, we consider the possibility of outsourcing beyond a city's boundaries (i.e., internationally).

The paper's analysis has four primary contributions. First, the paper shows that agglomeration reduces opportunism, and so serves as a substitute for integration. Second, the paper shows that the effect of agglomeration on opportunism and the organization of production is a force that will lead firms to agglomerate. Thus, in addition to the well-known technological agglomeration economies posited by Marshall, there also exist agglomeration economies that arise from organizational considerations. Third, the paper shows that the normative properties of equilibrium with local outsourcing are not as clear cut as for international outsourcing. There is no sense in which the world market can be excessively thick. Thus, an increase in the thickness of the world market – from increased openness, for instance – is welfare enhancing. The situation is more complicated for an increase in the thickness of a local market since agglomeration is achieved only at the cost of congestion of fixed factors such as accessible land. Thus, in contrast to international markets, local markets may be too thick. Fourth, the paper shows that the many changes in economic and social circumstance that have been labeled "globalization" do not only impact vertically integrated firms. The choice is not between vertical integration and outsourcing. It is instead the richer choice between vertical integration, international outsourcing, and local outsourcing. The most important implication of this is that international outsourcing reduces the value of home-country agglomeration, an effect that some believe might put the Silicon Valley in peril.

The remainder of the paper is organized as follows. Section II presents a model that illustrates the connection between the hold-up problem and market thickness. Section III develops a model where agglomeration increases market thickness. The model generates a joint solution for city size and organizational form. Section IV extends this analysis to consider the choice between vertical integration, local disintegration, and international disintegration.

II. A simple model of outsourcing

A. Primitives

This section presents a simple model of the outsourcing decision. In the next section we extend the model to examine how agglomeration influences outsourcing and the choice between vertically integrated and disintegrated organizational forms.

The model contains two types of firms: final goods producers (input demanders) and input suppliers. Demanders use specialized inputs to produce a homogeneous output, which we take to be the numeraire. Each supplier creates one unit of the specialized input at cost $c > 0$. These inputs are sold to demanders at prices determined through bargaining. We assume that input suppliers are small and that the number (mass) of suppliers, Q, is determined by free entry.

Both demanders and suppliers are described by addresses on a characteristic space that we suppose to be the unit interval.[3] The address of a demander, y, describes the type of input that it is best suited to employ. This address is exogenous. In this section we assume that there are just two demanders, with addresses $y_1 < y_2$, where $Y \equiv y_2 - y_1$ represents the distance between them in the characteristic space. This distance captures the thickness of the market. The next section extends the model to many demanders. The key property of this extension is that as the number of demanders increases, market thickness increases.

[3] The assumption of a linear characteristic space is not essential. Our qualitative results also hold for a circular characteristic space. We chose the unit line because it allows us to derive a number of results for the case when there are two demanders and then extend these results readily to the case of an arbitrary number of demanders.

The address of a supplier, $x \in [y_1,y_2]$, describes the type of input that it produces. This address is endogenous. If the address of an input does not exactly match the address of its employer, then the demander incurs a cost to modify the input. This adjustment cost is $a(d_{x,y})$ per unit, where $d_{x,y} = |x - y|$ is the distance in the characteristic space between demander and supplier. We assume that $a(\cdot)$ is increasing and strictly convex, with $a(0) = 0$.

Demanders can also create inputs internally. Obviously, internal inputs will be designed to exactly match the demander's input requirements; for these inputs, adjustment costs equal zero. The cost to a demander of making one unit of an input is assumed to be $k > c$. The cost difference between internal and external input production may reflect a managerial or organizational diseconomy associated with integrated production or a competency that allows dedicated input suppliers to produce at lower cost. When a firm makes some of its inputs, we say that the firm is vertically integrated. When a firm buys or outsources all of its inputs we say that the firm is vertically disintegrated.

The timing of decisions and events is as follows:

Stage I: Suppliers enter so long as their profits are non-negative. Each active supplier chooses a location to maximize profits and produces one unit.

Stage II: Input prices and the allocation of inputs to demanders are determined through bargaining. Demanders adjust the external inputs that they acquire to match their input requirements.

Stage III: Demanders choose levels of internal input production to maximize profits, and produce final goods.

We use backward induction to characterize an equilibrium, beginning with the internal production decision in Stage III.

B. Internal production

In Stage III, each demander produces inputs if it is profitable to do so. Let q_j represent the quantity of external inputs that demander j = 1,2 buys, and let q_j^0 represent the quantity of internal inputs that j makes. The output (and revenue) of demander j is written $f(q_j + q_j^0)$, where the production function $f(\cdot)$ is increasing and strictly concave.

If $q_j^0 > 0$, then the profit maximizing quantity of internal inputs equates marginal revenue and marginal cost:

$$f'(q_j + q_j^0) = k. \tag{1}$$

Conversely, $q_j^0 = 0$ is a maximizing choice when

$$f'(q_j) < k. \tag{2}$$

If marginal revenue is less than marginal cost for even the first internal input, then all inputs are purchased, that is, outsourced. In the former case, the demander is vertically integrated; in the latter case the demander is vertically disintegrated.

C. Outsourcing

1. Bidding for inputs

In Stage II, demanders make take-it-or-leave-it offers to input supplier. These offers can vary with supplier location. Since production costs are sunk at this point, each supplier accepts the highest non-negative bid for its input. This leads to the familiar problem of *ex post* opportunism: demanders have no incentive to offer prices that would support efficient external input production. Indeed, in the absence of competition between demanders, the equilibrium bid for any input would be zero, and an input market would not exist. However, in this model, there can be more than one bidder for each unit of input, and competition between bidders can limit opportunism.

To see this, consider a supplier located at x. The marginal value of this supplier's input to demander j, $v_j(x)$, is equal to marginal revenue less the associated adjustment cost:

$$v_j(x) \equiv f'(q_j + q_j^0) - a(d_{x,yj}). \tag{3}$$

Since adjustment cost $a(\cdot)$ is increasing in distance, the marginal value of the input decreases as $d_{x,yj}$ rises. We will, for simplicity, assume that all inputs have positive marginal value to all demanders: $v_j(x) > 0$ for all x and j = 1,2.[4] Using this notation, demander j's best response to a bid of $b_{j'}(x)$ by her rival is $b_j(x) = b_{j'}(x) + \varepsilon$, provided $v_j(x) > b_{j'}(x)$. If demander j' bids $b_{j'}(x) \geq v_j(x)$, then demander j's best response is to bid any amount less than the rival's bid. We will assume that demander j bids zero in this case.

In this situation, there is an equilibrium where the bid of a demander for a particular input equals the value of the input to its rival, provided this is not larger than the bidder's own valuation.[5] In this equilibrium, demander j = 1,2 bids

[4] It will be shown below that this is the only case that is relevant in equilibrium. A sufficient condition on primitives that supports this assumption is $\lim_{q\to\infty} f'(q) - a(1) > 0$.

[5] There are, however, other equilibria. For instance, if demander j' were to bid slightly less than demander j's value, it would be a best-response for demander j to bid her own marginal value, not the marginal value of the rival. This equilibrium is supported by a losing bid by demander j' that would never be made if the bidder thought that the bid might win.

$$b_j(x) = \begin{cases} v_{j'}(x) & v_j(x) \geq v_{j'}(x) \\ 0 & v_j(x) < v_{j'}(x) \end{cases}. \tag{4}$$

Figure 1 illustrates this bidding process. For the particular supplier location shown in the figure, demander 1, with the higher valuation, bids $b_1(x) = v_2(x)$, while demander 2, with the lower valuation, bids $b_2(x) = 0$.

Two remarks on the model are in order. First, we have assumed that demanders and suppliers cannot contract over prices or locations prior to input production. This incompleteness could arise if the quality of the input were not verifiable, since in this situation a demander would be unwilling to precommit to an input price. See Grossman-Helpman [19] for a formal treatment of this issue. Second, we have assumed that input demand is variable and that it exhibits a diminishing marginal product. This allows both demanders to derive positive marginal value from additional input supplies. This in turn allows both demanders to serve as outside options to input suppliers, reducing the ability of other demanders to opportunistically offer low input prices. This can be contrasted with a fixed input demand model, where each demander requires, for instance, one unit of input. In this case, once a particular demander has obtained its required input, it no longer provides an outside option in the bargain between another demander the input supplier, allowing other demanders to behave opportunistically. Grossman and Helpman [19] deal with this issue by supposing that a fraction of matches dissolves before production takes place. In the limit, as this fraction becomes small, the presence of other demanders curbs opportunism. McLaren [31] deals with the issue by sequencing the decisions and events so that outside options still have expected value when decisions are made. Our paper shows that another way to deal with the problem of the vanishing outside option -- and a reasonably natural one -- is to allow variable input demands. Variable input demand seems to be an appropriate assumption for many of the cases mentioned in the introduction. A jewelry manufacturer, for instance, chooses among various inputs -- both goods and services -- in order to create final products. The opportunity to substitute is great.

2. Input allocation and pricing

Input allocation and pricing are determined simultaneously. Since production costs are sunk in Stage II, each supplier accepts the highest bid for its input, provided the bid is non-negative. This implies that, as in an English auction, the price of an input equals its value to the second-highest bidder. Letting $p(x)$ represent the equilibrium price of an input supplied from x, we have $p(x) = \mathrm{Min}\{v_1(x), v_2(x)\}$.

These marginal values, and thus the price that a supplier receives, depend on the allocation of inputs to demanders. Let $q(x)$ represent an integrable density of suppliers across locations. The equilibrium allocation of inputs to demanders is determined by the critical supplier location x* such that $b_1(x^*) = b_2(x^*)$. Using (3) and (4), x* satisfies

$$f'(q_2 + q_2^0) - a(d_{x^*,y2}) = f'(q_1 + q_1^0) - a(d_{x^*,y1}), \tag{5}$$

where $q_1 = \int_0^{x^*} q(x)dx$, $q_2 = \int_{x^*}^1 q(x)dx$, and $q_1 + q_2 = Q$, the total quantity supplied. Following (4), demander 1 is the highest bidder for all inputs supplied from the interval $[y_1,x^*)$, while demander 2 is the highest bidder for inputs supplied from $(x^*,y_2]$. x* is the location where the two demanders' values are equal when all inputs are allocated to their highest bidder. The concavity of $f(\cdot)$ guarantees the existence of a unique $x^* \in (y_1,y_2)$ satisfying (5).[6]

[6] See the Appendix for details.

D. The entry and location of input suppliers

In Stage I, input suppliers enter the market individually, choose locations, and produce. With free entry, the equilibrium mass of input suppliers is determined by a zero profit condition. There are three forms that the equilibrium may take. First, it is possible that enough suppliers enter that there is no further incentive for internal provision of inputs, a fully disintegrated equilibrium. Second, it is possible that no suppliers enter, in which case the equilibrium involves fully integrated production. Third, it is possible that suppliers enter, but not in sufficient mass to completely discourage internal provision. This situation, where a demander both produces an input internally and purchases it from an external supplier, is referred to in the vertical integration literature as "tapered integration."

The following result is fundamental.

Proposition 1: All input suppliers between any two demanders locate at x^*.

Proof: The price that an input supplier receives equals the value of its input to the demander with the second-largest valuation: $p(x) = \text{Min}\{v_1(x), v_2(x)\}$. Thus, by construction the location x^*, where $v_1(x^*) = v_2(x^*)$ gives any input supplier the highest price. An input supplier at any other location would be better off moving to x^*, taking the allocation of inputs to demanders as fixed. This implies that no allocation with any input suppliers at any location other than x^* can be an equilibrium. By the same logic, if all input suppliers were located at x^*, none would have an incentive to deviate unilaterally. QED.

Proposition 1 shows that all input suppliers locate where the two demanders' marginal values are equal. When demanders are fully disintegrated, $b_j(x) = f'(q_{j'}) - a(d_{x,yj'})$, j, j' = 1,2, and so $v_1(x^*) = v_2(x^*)$ implies

$$f'(q_1) - a(x^* - y_1) = f'(Q - q_1) - a(y_2 - x^*). \tag{6}$$

In this case, the location at which p(x) is maximized varies with the allocation of inputs to demanders, and there are many values of x* that are consistent with equilibrium. If $q_1 > q_2$, then $x^* < (y_1 + y_2)/2$, while if $q_1 < q_2$, then $x^* > (y_1 + y_2)/2$. If $q_1 = q_2 = Q/2$, then $x^* = (y_1 + y_2)/2$. Since the problem we are considering is completely symmetric, this symmetric solution seems most natural. Also, all of the asymmetric equilibria (where $q_1 \neq q_2$) result in lower input prices. Thus, from the perspective of suppliers, the asymmetric solutions are in some sense dominated. For both of these reasons, we will focus on the symmetric outcome in what follows.[7] When demanders are vertically integrated (either fully or partially), by (1) and (3), $b_j(x) = k - a(d_{x,yj'})$, j, j' = 1,2, and so $v_1(x^*) = v_2(x^*)$ implies $x^* = (y_1 + y_2)/2$. Thus, in both the integrated and disintegrated cases, the distance between suppliers and demanders in the symmetric equilibrium is Y/2.

The task that remains is to determine the mass of input suppliers, Q. As discussed above, the equilibrium may involve complete disintegration, complete integration, or the intermediate case with tapered integration. In each of these cases, input suppliers enter until the marginal supplier earns zero profit. One consequence of this is that unless the marginal valuation is positive for both demanders, input price would be zero, and no input supplier would choose to enter. Thus, as assumed previously, it is not possible that either demander have non-positive marginal valuation in equilibrium.

[7] Another way to resolve this coordination problem would be to suppose that input suppliers entered sequentially.

We are now able to characterize the equilibrium make-or-buy decision. In the disintegrated case, the zero profit condition is

$$f'(Q/2) - a(Y/2) - c = 0. \tag{7}$$

The equilibrium mass of input suppliers Q is implicitly defined by (7). It is a decreasing function of the cost of external input production and of the distance between the demanders. From (2), $q_j^0 = 0$ requires $f'(Q/2) < k$. Combining this with (7) implies that production is fully disintegrated in equilibrium when

$$k - c > a(Y/2). \tag{8}$$

Intuitively, demanders will be disintegrated in equilibrium when the cost disadvantage of internal production is larger than the loss associated with imperfect input specialization. The disintegrated equilibrium is illustrated in Figure 2. Given Q and $x^* = (y_1+y_2)/2$, the input is allocated so that marginal valuations are equal. Q then adjusts so that marginal value equals marginal cost. Marginal cost plus the adjustment costs in equilibrium must be less than the cost of integrated production, which holds as Figure 2 is drawn. The lower panel in the figure shows the price that an individual input supplier would receive taking as given the locations of all other input suppliers. As it must be, it is maximized at $x^* = (y_1 + y_2)/2$.

Turning now to the fully integrated case, if no input supplier could enter at the profit maximizing location and earn non-negative profit,

$$f'(q_j^0) - a(Y/2) - c < 0, \tag{9}$$

then final goods producers will be integrated in equilibrium. Here the level of internal provision satisfies $f'(q_j^0) = k$, from (1). Combining this with (9) implies that production is fully integrated in equilibrium when

$$k - c < a(Y/2). \tag{10}$$

In this case, the demanders' cost disadvantage is small relative to the adjustment costs that would be incurred in the disintegrated equilibrium. The integrated equilibrium is illustrated in Figure 3.

The final possibility is a tapered integration equilibrium. This is a knife-edge in this model. In this case, zero profit for input suppliers requires

$$f'(Q/2 + q_j^0) - a(Y/2) - c = 0 \tag{11}$$

where the level of internal provision satisfies $f'(Q/2 + q_j^0) = k$, from (1). Combining this with (11) implies that a tapered integration equilibrium is only possible when the cost disadvantage associated with integrated production exactly equals the loss associated with imperfect input specialization:

$$k - c = a(Y/2). \tag{12}$$

This analysis may be summarized as follows:

Proposition 2: The symmetric equilibrium is disintegrated, integrated, or tapered as k - c is greater than, less than, or equal to a(Y/2).

Proof: See above.

E. Interpretation

Proposition 2 shows that the organizational nature of the equilibrium -- vertically integrated or not -- depends on the cost advantage of outsourced production, the cost of adjusting an input, and the density of input demanders. Both the cost advantage and the adjustment cost are technological. If the technology is such that adjustment costs are small at a given distance, then outsourced production need have only a small cost advantage in order to lead to the disintegrated equilibrium. If adjustment costs are large, however, then the cost advantage would need to be greater. By itself, this suggests that goods where production is a matter of routine and adjustment costs are therefore small can readily disintegrate production. Goods where adjustment is costly are less likely to be able to operate in a disintegrated fashion.

The density of input demanders, on the other hand, is not determined by the technology. When input demanders are similar, $Y = y_2 - y_1$ is small, which may allow disintegration even when production is not routine and so adjustment costs are large. As discussed in the next section, the distance between demanders is more likely to be small in a big city. This is consistent with Vernon [41], who makes much of the industrial organization in the New York Metropolitan Region in industries where production is "unpredictable" such as high-fashion apparel.

It is worth pointing out that the organizational nature of the equilibrium is uniquely determined in our model. There is either disintegration or integration, depending on the values of the model's key parameters. This is a consequence of the structure of the game. The key assumptions are variable input demand and that demanders are allowed to supplement outsourced inputs with internal production after the input suppliers make their decisions. If we had instead supposed that there were fixed input demands and that demanders must choose whether or not to produce the input internally prior to the operation of the input market, as in Grossman and Helpman [19], then there would have been multiple equilibria. If demander 2 chose in advance to obtain all its inputs internally, then demander 1 would do the same, since the absence of competition for inputs would discourage the entry of independent input suppliers.

This brings home the point that the integration decision of a rival can affect the choice of another demander in some situations. Another situation where this can occur is when the two demanders are in some way different. For instance, suppose that demander 1 can produce internally at lower cost than can demander 2, $k_1 < k_2$. If k_1 is sufficiently close to c, then demander 1 will acquire the input internally. This, in turn, could discourage independent input supplier entry, forcing demander 2 to integrate as well.

III. Agglomeration and opportunism

A. Many demanders

The previous section used a two-demander model to characterize equilibrium outsourcing. This section extends the two-demander model to the case where a city contains an arbitrary number of demanders, $J \geq 2$. We begin by taking J as exogenous, but we later consider the optimum and equilibrium number of demanders. Extending the model to more than two demanders allows us to examine the relationship between agglomeration, opportunism and outsourcing. In order to focus on the latter two issues, we do not include any other sort of agglomeration economy in our model.

One of the merits of the model described in Section II is that its extension to more than two demanders is natural. For any input supplier, only the nearest demanders are relevant, since any more distant demander could be outbid by one of these. Consequently, a supplier in a market with many demanders faces exactly the same choices as in the two-demander case: it enters if profits are non-negative and chooses a location between two demanders to maximize profits. Also as before, input demanders choose whether to procure inputs internally or externally. In the case of external provision, the price reflects bidding against at most one other demander for the input of a particular supplier.

Our approach to market thickness is to assume that the distance between neighboring firms in the characteristic space becomes smaller when activity is concentrated in a city or region. Thus, agglomeration increases density, in this case the density of input demanders. Formally, we suppose that the demanders are evenly spaced on the unit line with addresses $y_1, y_2, \ldots, y_J$, where $y_j = (j-1)/(J-1)$. We continue to denote by Y the distance between neighboring demanders. Keeping the characteristic space of constant unit length means that $Y = y_{j+1} - y_j = 1/(J-1)$. An increase in the number of demanders in a city is associated with a decrease in the characteristic space distance between any two. As in Section II, we restrict out attention to outcomes with input supply locations that are exactly between the demanders. This means that the input supply locations $x_1, x_2, \ldots, x_{J-1}$ satisfy $x_j = (2j-1)/(2(J-1))$, implying that the distance between an input supplier and its nearest demanders is $d = 1/(2(J-1))$.

It is worth reiterating that in our approach to market thickness, the addresses of demanders vary with the number of demanders in a deterministic way. This specification has the property that an increase in the number of demanders (agglomeration) increases market thickness. If we instead allowed demanders to choose locations without changing anything else in the model, they would locate together. In this case, the presence of two demanders would be sufficient for a perfectly thick market. This is obviously unappealing, hence our approach. As a modeling strategy, ours should be thought of as being parallel to the Dixit-Stiglitz [9] model of monopolistic competition, where firms also do not choose the characteristics of the products that they supply.[8]

[8] An alternative would be to suppose that demanders' location choices impact product market competition. In this case, if firms chose the same location in the characteristic space, product market competition would reduce their profits. In the extreme case of Bertrand competition in the product market, demanders would earn zero profit if they chose the same location. See D'Aspremont et al [6,7] for a formal treatment of this.

As in our earlier analysis, the distance between any pair of input suppliers may be sufficiently large that opportunism prevents the operation of a disintegrated input market. This will be the case when there are few demanders. Stated more formally:

Proposition 3. Vertical disintegration requires a sufficiently thick market.

Proof: Following the analysis in Section II, a disintegrated input market cannot operate when an input supplied at the midpoint between two demanders involves adjustment and production costs that exceed the cost of internal production. Substituting for $Y = 1/(J - 1)$ in (8), production will be fully disintegrated in the equilibrium with many demanders when

$$k - c > a\left(\frac{1}{2(J-1)}\right). \tag{13}$$

(13) defines a critical level of J, denoted $\tilde{J}$ such that for $J < \tilde{J}$, equilibrium involves integrated production. For $J \geq \tilde{J}$, equilibrium involves disintegrated production. QED

Proposition 3 implies that agglomeration is a substitute for vertical integration. When the market is thin, as it would be outside an agglomeration, there is at best a weak outside option to protect an input supplier from the opportunism of downstream firms. This result accords nicely with the discussion of business services in the introduction, where larger cities were shown to exhibit more outsourcing. Proposition 3 is also consistent with Holmes' [26] finding that purchased input intensity -- the value of purchased inputs divided by the value of total output -- is greater the greater is the same-industry employment within 50 miles. The result is also consistent with Ono's [33] demonstration that the probability of outsourcing is greater in a larger market and with the Garicano and Hubbard [16] result that the "field scope" of law firms is narrower in a larger market, with a smaller proportion of activity carried out by general purpose firms.[9]

For, $J > \tilde{J}$, a Nash equilibrium with disintegrated production is as discussed in Section II: the price of any input equals the highest and second highest marginal value of the input and the marginal cost of input production; input supplies are allocated among demanders so that the marginal values are equal and aggregate supply equals aggregate demand; and inputs are supplied at the location exactly between the input demanders. The location condition has already been given. The other conditions simplify to:

$$f'(q) - a\left(\frac{Y}{2}\right) - c = 0, \tag{14}$$

and

$$(J-1)Q - Jq = 0. \tag{15}$$

(14) is a restatement of the zero profit condition. (15) ensures that the aggregate input supply, $(J - 1)Q$, equals aggregate input demand, Jq. Although all input supply locations are symmetric in that they produce the same amount of the input, the equilibrium is not completely symmetric because the input suppliers do not necessarily sell half to one supplier and half to the other. To see this, suppose that there are 3 demanders and 2 input supply locations. Each location will produce $3q/2$ of the input. Of the input at location x_1, q goes to demander 1, while $q/2$ goes to demander 2; at x_2, q goes to demander 3 and $q/2$ to demander 2. This asymmetry arises because the characteristic space has endpoints.

[9] Proposition 3 is also at least loosely consistent with Rosenthal and Strange [34] and Henderson [25]. The former shows that a larger agglomeration effect is exerted by small firms, while the latter shows that a larger external effect is received by small firms. It should be noted, however, that both of these results relate to agglomeration economies in general and not to input sharing in particular.

For future reference, (14) defines a relationship between the input quantity, q, and the number of demanders, J. Differentiating, and recalling that Y = 1/(J – 1), we have

$$\frac{dq}{dJ} = -\frac{a'\left(\frac{Y}{2}\right)}{2(J-1)^2 f''(q)} > 0\,. \tag{16}$$

As J grows, adjustment cost for an external input decreases, and this causes demanders to increase external input use in equilibrium. From (15),

$$\frac{dQ}{dJ} = \frac{J}{J-1}\frac{dq}{dJ} - \frac{q}{(J-1)^2}\,. \tag{17}$$

Each supply address provides a share 1/(J – 1) of the aggregate input demand. Although aggregate demand rises with J, the share supplied from any address falls with J. As a result, the impact of an increase in J on supply at a particular address is ambiguous.

One of the interesting features of this model is that it is advantageous for firms to cluster, even though there are no economies of scale in input production. The advantage arises from the reduction in opportunism that occurs as the thickness of local inputs markets increases. In this model, J represents the agglomeration of demanders into a particular city.

Proposition 4. An input demander's profit increases with the number of rival input demanders.

Proof: The profit of any demander in the disintegrated equilibrium can be written as revenue minus adjustment cost minus input costs:

$$\pi = f(q) - \left(a\left(\frac{Y}{2} \right) + c \right) q. \tag{18}$$

Differentiating with respect to J, and using (14) and Y = 1/(J – 1) gives

$$\frac{d\pi}{dJ} = \frac{a'\left(\frac{Y}{2} \right) q}{2(J-1)^2} > 0. \tag{19}$$

QED

This effect occurs despite the competition between demanders for inputs. The reduction in opportunism results in an increase in q for each demander by (16), and this leads to an increase in profit as input demanders agglomerate.[10]

Proposition 4 establishes the existence of an agglomeration economy that is strikingly non-Marshallian. As is well known, Marshall [28] identifies knowledge spillovers, labor market pooling, and input sharing as being sources of external economies. The cases of knowledge spillovers and labor market pooling are not especially relevant here, but the case of input sharing is.[11] The key to the Marshallian analysis of input sharing is scale economies. As in Smith [38], the division of labor is limited by the extent of the market. Agglomeration allows inputs to be shared in the sense that scale economies can be realized with an extensive market, but not when production takes place in isolation. In this model, however, there are no scale economies involved in input production. Instead, the gains from agglomeration come from a reduction in opportunism. The agglomeration economy is based, therefore, on

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[10] We have assumed away competition in local product markets in order to focus on input markets. If there were product market competition, this would weaken the tendency to agglomerate. Clearly, the opportunism effect dominates for goods sold on national and international markets.

[11] See Glaeser [17] or Helsley and Strange [23] respectively for models of knowledge spillovers and labor market pooling.

transactions costs rather than on the purely technological agglomeration economies considered by Marshall. In a sense, this agglomeration economy can be seen as being Williamsonian, rather than Marshallian.

Nearly the entire microfoundations literature to date has considered Marshallian agglomeration economies. See Quigley [32] for a survey. Goldstein and Gronberg [18] is typical. They consider input sharing in cities, arguing that input sharing leads to geographically defined economies of scope. They note that large cities allow vertical disintegration because of the availability of an "urban warehouse" (p. 95). However, although they cite Williamson's work, they do not make a connection between opportunism and relationship specific investment, instead focusing on the properties of cost curves. A recent exception in its focus on transactions costs and agglomeration is Rotemberg and Saloner [35], who consider the incentive of a worker to acquire industry-specific human capital. In their model, the Bertrand competition for workers by employers ensures that workers will be paid their marginal products, which in turn encourages them to acquire human capital. Because of the Bertrand competition, it does not matter how many employers are clustered as long as there are at least two. This is not, of course, true in our model. In addition, Rotemberg and Saloner do not consider the degree to which agglomeration and vertical integrations are strategic alternatives in dealing with opportunism.[12]

In this model so far, there is a monotonic relationship between the number of demanders and profit. This is parallel to the analysis of the thickness of world markets by Grossman-Helpman [19] and McLaren [31] where increased thickness is always a blessing. An increase in a city's thickness is not costless, however. The next section considers the implications of this.

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[12] More recently, Combes and Duranton [5], Matouschek and Robert-Nicoud [29], and Almazan et al [1] all consider the incentives to invest in human capital. Like Rotemberg and Saloner [34], none of these consider the possibility of vertical integration.

B. The thickness of local input markets

Local outsourcing is limited by fixed factors in ways that international outsourcing may not be. There are many factors that may play this limiting role. Transportation systems are certainly subject to congestion. Air quality may decline as industrial and transportation activities expand. Accessible land becomes scarce as a city grows.

To illustrate the impacts of fixed factors on the thickness of local input markets, suppose now that input demanders incur an additional cost C(J) that increases with the number of demanders.[13] In this case, the profit of any demander in the disintegrated equilibrium is $\Pi = \pi - C(J)$, where π is given in (18). The relationship between the profit of a demander and the number of demanders becomes

$$\frac{d\Pi}{dJ} = \frac{d\pi}{dJ} - C'(J), \tag{20}$$

where $d\pi/dJ > 0$ by (19). The first term in (20) is the positive impact of an increase in the number of demanders through the Williamsonian agglomeration economy. By (19), the limit as J goes to infinity of $d\pi/dJ$ is zero by the assumption that $a(0) = 0$. The second term represents the negative impact of congestion. Since C(J) is globally increasing, the congestion effect will eventually dominate the Williamsonian agglomeration economy, and the profit of an individual demander will decline with further increases in J. With

[13] C(-) includes both the direct congestion effect imposed by other demanders and the indirect effect associated with input suppliers through the dependence of Q on J as in equation (17). One natural microfoundation for these congestion costs can be found in the operation of urban labor markets. If producers employ both labor and specialized inputs, and if workers commute to a common employment center, then the equilibrium wage must rise with the number of producers to enable workers to compete successfully for land.

congestion arising from the presence of fixed local factors, the benefits of agglomeration do not increase monotonically with the number of demanders.

This naturally leads us to examine the determinants of the number of final goods producers. It is easiest to begin with an optimum program. Suppose that there are many potential city sites in the economy and that a planner is charged with allocating a large number of final goods producers to city sites to maximize aggregate profit.[14] Suppose further that the planner cannot directly control the locations or production decisions of input demanders or suppliers.

Under these conditions, the planner should choose for each site the value of J that maximizes the profit of an individual demander. There are two regimes. In the first, production is integrated and the optimum number of firms is J = 1. In this model, whenever there is integration, congestion costs encourage spatial decentralization since there is a cost to agglomeration (congestion) but no benefit (the only agglomeration economy relates to external sourcing of inputs). In the second regime, firms are vertically disintegrated, and the optimum number of firms J* satisfies $d\Pi/dJ = 0$, or

$$\frac{d\pi}{dJ} = C'(J) \tag{21}$$

from (20). At J*, the marginal benefit of another input demander, the increase in profit associated with the reduction in opportunism, is just balanced by the marginal cost of congestion. The second-order conditions require that the function Π be strictly concave over the range $J > \tilde{J}$. In this case, the choice between the two regimes depends on the global level of demander profit.

[14] A more involved analysis would specify a land market explicitly. In this case, the objective would also include aggregate land rents. This would not change the qualitative results, so we have retained the simpler specification.

The equilibrium is determined by the profit maximizing entry and location decisions of demanders. Once again, there are two regimes. If $\Pi(1) > \Pi(J^*)$ and $\Pi(1) > 0$, then active demanders choose integrated production and there is one firm at each site. In this case, the equilibrium and optimum coincide. If $\Pi(1) \leq \Pi(J^*)$, and $\Pi(J^*) > 0$, then active demanders choose disintegrated production, and the equilibrium number of firms at any site J^L satisfies $\Pi(J^L) = 0$. In the case shown in Figure 4, obtained by assuming quadratic functional forms for f(q), a(d), and C(J), there are then two candidate values for J^L, corresponding to the two roots of $\Pi(J^L) = 0$. However, any root smaller than J* is unstable, since profit is increasing in the number of demanders there. This implies that for $\Pi(1) \leq 0$, and $\Pi(J^*) > 0$, $J^L > J^*$. Individual demanders ignore the impact of their decisions on the level of profit, and this leads to excessive entry. Thus, with congestion arising from fixed factors, local outsourcing can involve input markets that are too thick, in marked contrast to many of the results in the literature on national and international outsourcing.

There is one other case in the disintegrated regime that is of interest. If $\Pi(J^*) > \Pi(1) > 0$, then J^L satisfies $\Pi(J^L) = \Pi(1)$. In this case, entry does not drive profit to zero. Rather, the equilibrium level of profit in an agglomeration equals the level that a firm could earn in autarky with integrated production. This implies that integrated and disintegrated firms may coexist in equilibrium, where the former locate in isolation, and latter locate in clusters larger than J*. As discussed above, there is excessive entry in sites where production is disintegrated. In this case also, input markets can be too thick.

IV. Globalization and cities

The paper has thus far considered two related aspects of the organization of production: whether production should involve vertical integration and whether firms should agglomerate. There have been several recent papers that have considered the parallel issue of the international vertical disintegraton of production. As noted earlier, Feenstra [14] documents the increasing international component of vertical disintegration and reviews its sources and consequences, especially for wages. McLaren [30] and Grossman and Helpman [19,20] present models that illuminate the process. The heart of these models is that increasing international openness leads input markets to be thicker. Thicker markets allow a disintegrated equilibrium, although the complete integration of production remains an equilibrium as well. Thus, reductions in trade barriers, part of the broad phenomenon of globalization, are naturally accompanied by an increase in vertical disintegration. Feenstra [14, p. 31] writes that increases in international outsourcing "represent a breakdown in the vertically integrated model of production -- the so-called 'Fordist' production, exemplified by the automobile industry -- on which American manufacturing was built." The choice is thus between integrated production and disintegrated production, with the latter sometimes involving offshore input production. Agglomeration is not part of this analysis at all.

We will conclude the paper by adding an international dimension to our model. As will be seen, there is an effect of globalization that has been ignored in analyses of home and offshore production that do not consider agglomeration.

We will begin with the model of agglomeration and vertical integration from Section III. The key modification will be that a demander now has the option to obtain inputs from the world market, rather than from local sources. We refer to this as obtaining the inputs internationally, although the source could, in fact, be from within a demander's region or nation. We suppose that there is a transportation cost associated with accessing the world market. Specifically, we suppose that the per unit cost of obtaining the input internationally is τ. These transportation costs should be broadly conceived, including both actual transportation costs and various border costs.[15] Gravity models of trade (for instance., Baier and Bergstrand [2]) show these costs to be important. We suppose that the cost of producing the input internationally remains c and that the cost of integrated production remains k. It is possible, perhaps likely, that the costs would differ. Taking the home market as a developed country, the direction of the difference is not completely clear, however, with low labor costs in less developed countries weighed against high productivity in developed countries. In contrast, the effects of globalization on market thickness are unambiguous. We will denote by J^W the number of demanders on the world market. It is natural to suppose that this exceeds the equilibrium number of local demanders in a city: $J^L < J^W$.

Knife-edges aside, a demander now has three choices: produce internally, disintegrate locally, and disintegrate internationally. The cost per unit of input under internal production is k, as before. Recognizing that the equilibrium distance to a supplier is $1/[2(J^L\text{-}1)]$, the per unit cost under local disintegration is $c + a(1/[2(J^L\text{-}1)])$,

[15] It is worth emphasizing that these transportation costs are conceptually distinct from the adjustment costs discussed so far.

also as before. Similarly, the per unit cost under international disintegration is $c + a(1/[2(J^W -1)]) + \tau$. Thus internal production is chosen when

$$k - c < \min \{a(1/[2(J^L-1)]), a(1/[2(J^W -1)]) + \tau\}, \tag{23}$$

while local disintegration occurs when

$$a(1/[2(J^L-1)]) < \min \{k-c, a(1/[2(J^W -1)]) + \tau\}. \tag{24}$$

International disintegration takes place when

$$a(1/[2(J^W -1)]) + \tau < \min \{k-c, a(1/[2(J^L-1)]) \}. \tag{25}$$

The choice between these alternatives is illustrated in Figure 5. The figure shows the organization of production that would arise in equilibrium as a function of $k - c$ and τ, the cost advantage of outsourcing and transportation costs. There are two ways to read the figure. First, looking at an industry with a particular value of $k - c$, the organization of production may depend on the cost of transportation. For high values of $k - c$, high transportation cost industries are outsourced locally. For low transportation costs, the outsourcing is international. For these industries, the cost advantage of outsourced production is too great for vertical integration to occur. For intermediate values of $k - c$, specifically for $a^W \equiv a(1/[2(J^W -1)]) < k - c < a(1/[2(J^L-1)]) \equiv a^L$, high transportation costs imply vertical integration, while low transportation cost industries outsource internationally. Finally, for low values of k - c, the cost advantage of outsourcing is so low that vertical integration is always the best remedy for the problems of opportunism.

The second way to look at the figure is to consider the impact of the cost advantage of outsourcing for given transportation costs. The case of high transportation costs gives vertical integration for low k - c and local outsourcing for high values. This is the case considered in Proposition 2. For $\tau < a^L - a^W$, the choice is between international outsourcing and vertical integration.

It has been argued that international outsourcing is in part as a consequence of declines in transport costs (see Baier and Bergstrand [2]). The integrate-or-disintegrate-internationally analysis that underlies this view is neutral with regard to the impact of declines in transport costs on cities. The analysis here shows that international outsourcing is not simply an international devolution of previously integrated firms, but is also a devolution of disintegrated local production systems. Declines in transport costs may, therefore, have a profound effect on cities.

Some believe that these effects are beginning to be felt in the Silicon Valley. The population of San Francisco, a home to many Silicon Valley workers, fell by 1.5% in 2002. The population of San Jose fell by 0.6%. This decline in aggregate population has accompanied a decline in the area's premiere industry, software. Employment in this industry is down 22% since its peak, and total unemployment is 8.5%. At the same time, local employers are shifting activities offshore, especially to India (Business Week [3]). Forrester, an industry analyst, notes that more than half of Fortune 1000 companies have not outsourced any of their information technology work, suggesting that the process of "offshoring" services has barely begun (Economist [13]). Intel's Andy Grove goes so far as to suggest that only a "miracle" could prevent the U.S. software industry from following the path of the steel and semiconductor industries, where the U.S. share of world production fell drastically over a few decades. There are, however, reasons for hope. Although, as this paper has argued, one of the forces leading to agglomeration has been weakened, there are many other agglomeration economies that are still present. These may continue to place the Silicon Valley at the center of world high technology, even when the benefits of reduced opportunism have been eroded.

Appendix

This appendix discusses the existence of a unique $x^* \in (y_1,y_2)$ satisfying (5). Define

$$F(x^*) = f'(q_1 + q_1^0) - f'(q_2 + q_2^0) + a(d_{x^*,y2}) - a(d_{x^*,y1}), \tag{A1}$$

where $q_1 = \int_{y_1}^{x^*} q(x)dx$, $q_2 = \int_{x^*}^{y_2} q(x)dx$, $q(x)$ is the density of suppliers, and $q_1 + q_2 = Q$, the total quantity supplied. A value of x^* such that $F(x^*) = 0$ is a solution to (5). If both demanders are vertically disintegrated, then (A1) becomes

$$F(x^*) = f'(q_1) - f'(q_2) + a(d_{x^*,y2}) - a(d_{x^*,y1}). \tag{A2}$$

Note that in this case

$$F'(x^*) = f''(q_1)q(x^*) + f''(q_2)q(x^*) - a'(y_2 - x^*) - a'(x^* - y_1) < 0, \tag{A3}$$

by the concavity of $f(\cdot)$. Further,

$$F(y_1) = f'(0) - f'(Q) + a(Y) > 0, \tag{A4}$$

while

$$F(y_2) = f'(Q) - f'(0) - a(Y) < 0, \tag{A5}$$

again, by the concavity of $f(\cdot)$. Thus, by continuity and the mean value theorem, there must exist an $x^* \in (y_1,y_2)$ such that $F(x^*) = 0$. Since $F(\cdot)$ is monotonic, this solution is unique. As discussed in the text, if both demanders are vertically integrated, then existence and uniqueness are assured, since $x^* = (y_1 + y_2)/2$.

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Figure 1. The bidding process

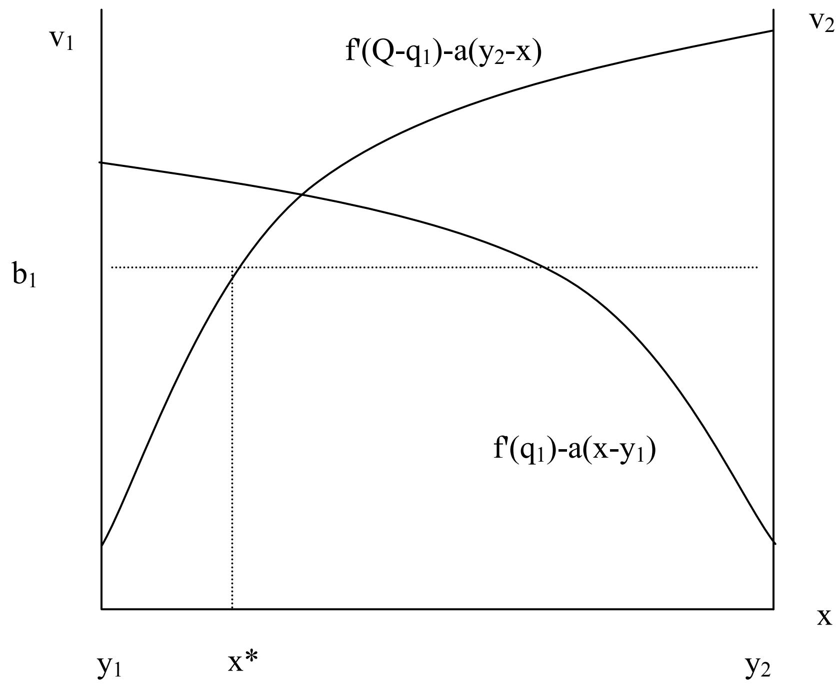

Figure 2. A symmetric equilibrium with vertically disintegrated production

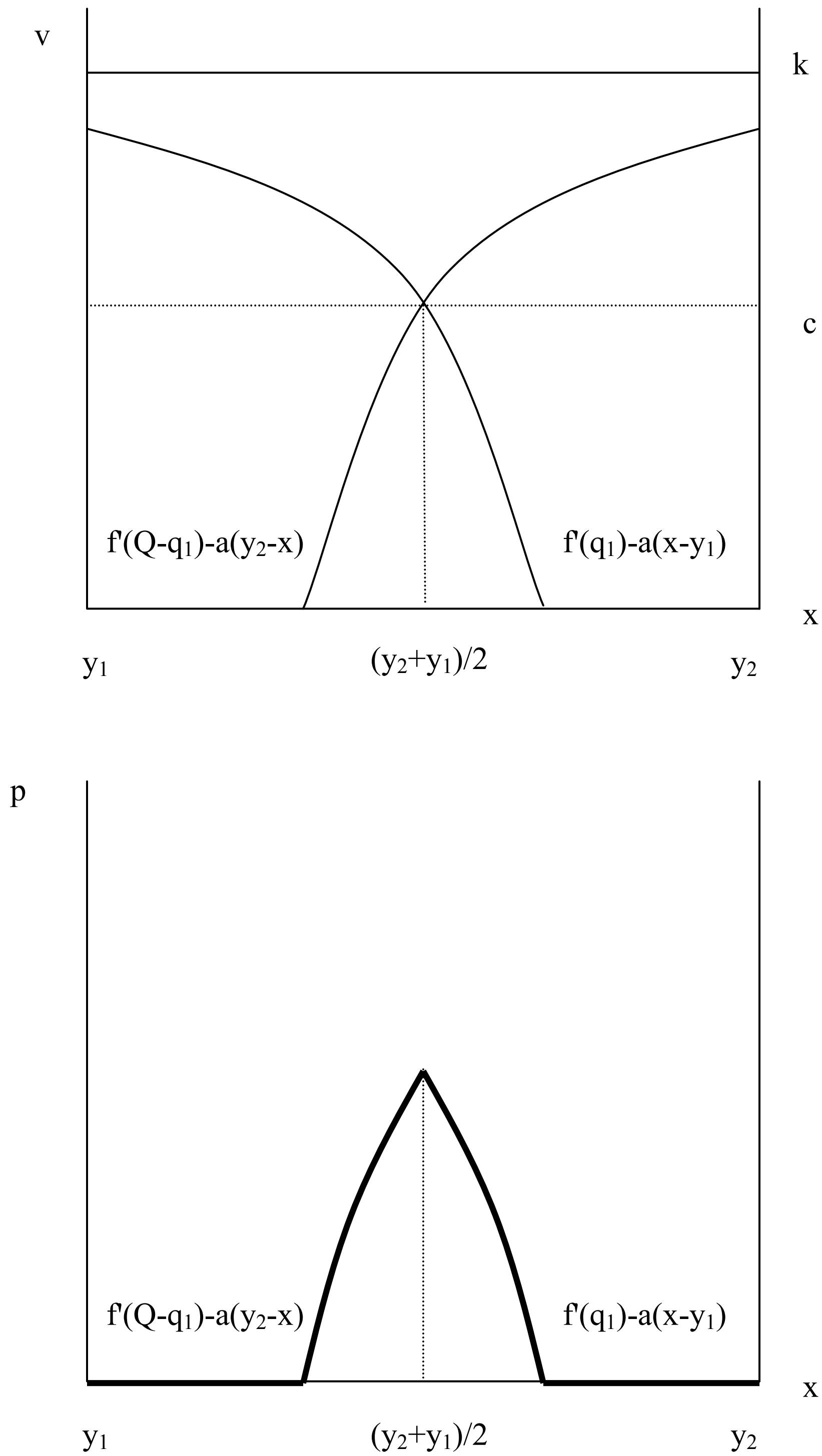

Figure 3. **A fully integrated equilibrium**

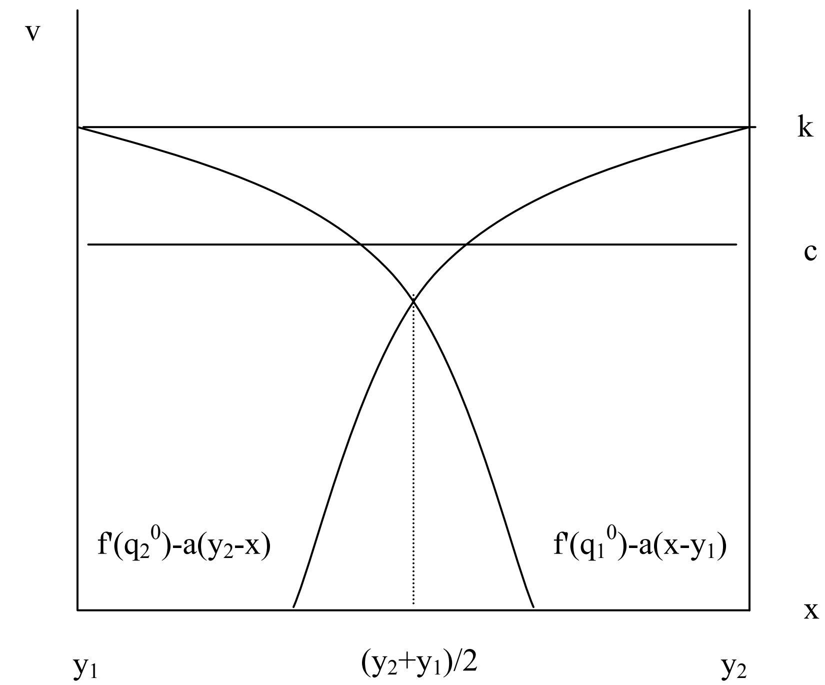

Figure 4. **Optimum and equilibrium numbers of demanders**

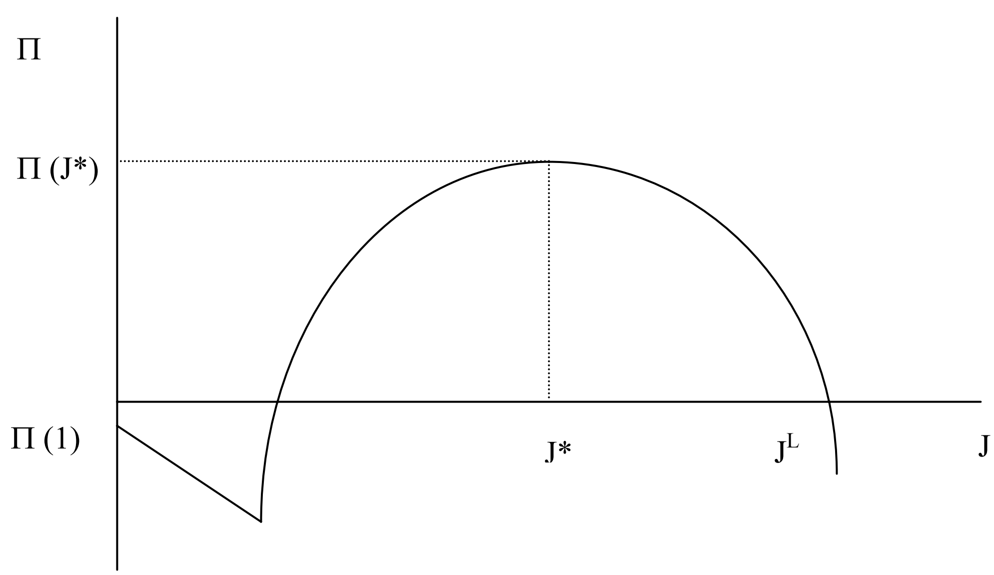

Figure 5. Globalization and the organization of production.