"Globalization" and Vertical Structure

By John McLaren*

This paper analyzes the effects of international openness on vertical integration. Vertical integration can confer a negative externality, by thinning the market for inputs and thus worsening opportunism problems; this induces strategic complementarity and multiple equilibria in the integration decision, thus providing a theory of different "industrial systems" or "industrial cultures" in ex ante identical countries. International openness thickens the market, facilitating leaner, less integrated firms, thus providing gains from international openness quite different from those that are familiar from trade theory. This may be taken as one theory of "outsourcing," "downsizing," and "Japanization" as consequences of "globalization." (*JEL* D23, F15, L22)

Differences across countries and across time in the degree of vertical integration are central to many economic issues. For example, the phenomenon of "downsizing" often has a large element of vertical divestiture, and is related to increases in "outsourcing" observed in recent years in many areas of business.[1] The differences in industrial "systems" across countries, between the U.S. and Japanese economies, for example, have much to do with differences in vertical structure, with Japanese industry very much less integrated than its major trading partners.[2] Other much-noted examples are the tremendous contrast between industrial systems in South Korea and Taiwan,[3] between the Emilia-Romagna region of Italy and the rest of Europe,[4] and between the U.S. and British textile industries of the first half of the nineteenth century.[5]

Many of these phenomena are claimed by some observers to have a close relationship with international trade. For example, downsizing is held to be a response to increased foreign competition; the leaner organizational structure of Japanese industry allegedly has given it some advantages which have forced a partial "Japanization" of some Western industries (see, for example, Gertler [1991]). However, there does not appear to be a body of theory within international economics to rationalize this idea, or to address these questions. Can a rise in openness affect the vertical structure of industry in a predictable way? If a leaner organizational

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[1] See Elizabeth Gardner (1991) for the rise in outsourcing of data management by hospitals; *Bank Systems & Technology* (1991) on outsourcing of technology by banks; Peter Buxbaum (1994) on the recent outsourcing of distribution services by GM; James Bamford (1994) on the recent trend toward outsourcing of parts in the U.S. automotive sector; Edward J. Bardi and Michael Tracey (1991) on the move toward greater outsourcing of transport services across manufacturing; and *The Economist* (1991) for an overview of the trend toward outsourcing in manufacturing in general.

[2] See Toshihiro Nishiguchi (1994) for an extensive analysis of the Japanese case; Meric S. Gertler (1991) and Jonathan Morris (1991) offer comparisons with North American industry. See also *The Economist* (1991).

[3] The former is far more vertically integrated. See Brian Levy (1991) and Robert C. Feenstra et al. (1997).

[4] This region has evolved a distinctive style of highly vertically disintegrated production. See Russell Johnston and Paul R. Lawrence (1988) and Gertler (1991 pp. 380–85).

[5] The former was much more integrated; see Peter Temin (1988).

structure really is a lower-cost way of procuring inputs,[6] why would, say, an American auto firm wait until it is battered by competitors to implement it? Why would a profit-maximizing corporation not always choose to minimize costs? Further, does any of this have welfare implications?

This paper analyzes the effects of international openness on the vertical integration decision in an industry equilibrium, and suggests that openness can indeed have strong effects on vertical structure, and that this can have large welfare effects. The outlines of the argument, which is based on a simple "transactions-cost" model, are as follows. Suppose that each of a number of final goods producers ("downstream firms," or DSF's) tries to procure a specialized, indivisible input from a supplier (or "upstream firm," or USF). There are two possible procurement methods: "arm's-length," or market, procurement; and "integrated" procurement. In the former, the two firms form an understanding, perhaps through a verbal agreement, and come to terms on payment when the unit is ready. In the latter, some costly commitment technology is brought to bear, either a long-term contract or a merger between the two enterprises.

Because of the sunkeness of the cost of producing the input and its specialized nature, the USF knows that under the arm's-length arrangement it is in danger of being "held up" by the DSF and not recouping its costs *ex post.* Its only reassurance is that there may be alternative buyers for the input, whose presence will give the USF bargaining power and allow it to demand a remunerative price. Thus, in the absence of a robust potential market for the input, the USF may judge the input to be an unremunerative product and abandon it. The alternative is the integrative arrangement, but this has its own disadvantages, either legal costs from negotiating and enforcing a contract or the costs of a merger and its attendant heightened "governance costs."

Thus, as argued in an extensive literature, each DSF/USF pair in the industry chooses between the two methods by trading off the hold-up problem of arm's-length trade against the governance costs of the integrated solution. However, three consequences of this reasoning are derived here that are not much acknowledged in the existing literature. First, the feasibility of the arm's-length system depends on the USF's prospects for recovering its sunk costs on the open market; but these prospects are better the more of the other firms have chosen arm's-length arrangements (or, the "thicker" is the market for inputs). The reason is that the equilibrium price received by an unintegrated supplier is determined by the input's *most attractive alternative use,* and the expected value of this is higher, the more alternative uses there are. Since an unintegrated DSF is much more likely than an integrated one to be a potential alternative user for inputs from independent suppliers, it is thus natural that a rise in the number of unintegrated firms makes unintegrated supply more remunerative. This is Proposition 5 of the paper. Thus, there is a negative externality from vertical integration, making arm's-length arrangements less feasible for others, and so there tends to be too much integration in equilibrium.[7] For this same reason there is a "strategic complementarity" in the vertical integration decision, so if the firms in the industry are sufficiently similar, there can be two equilibria: one with each firm choosing integration, and the other with all input suppliers remaining independent. One interpretation of this is that two otherwise identical countries can evolve completely different industrial systems, as the case studies cited above suggest, without in any way departing from strict assumptions of economic rationality or profit maximization.[8]

Second, an additional means of thickening the secondary market is to open up the economy to international trade. If two countries have similar industries facing the hold-up problems described above, then lowering trade costs between them will make it easier for an input supplier to find an attractive alternative buyer

[6] As argued forcefully by, among many others, *The Economist* (1991) and Nishiguchi (1994). See also the recent consultant's report on the U.S. auto industry cited in Micheline Maynard (1996), which pushed outsourcing very hard.

[7] Other models of vertical integration that feature excessive integration include Patrick Bolton and Michael D. Whinston (1993) and Winand Emons (1996).

[8] Feenstra et al. (1997) provide a complementary theory of multiple equilibria in vertical structure, based on a "double marginalization" motive for vertical integration.

abroad, thus strengthening its bargaining power *ex post* and making an arm's-length arrangement more attractive. Thus, international trade can lead to a substantial decrease in the incidence of integration.[9] Further, procurement systems across countries will tend to "converge" with increased openness. There is, in addition, a sense in which increases in arm's-length trade tend to be "internationally contagious."

Third, since a thickening of the market simply gives each firm more options in its procurement strategy, the effects of the opening up of trade on vertical structure are unambiguously efficiency enhancing. They thus provide an avenue for efficiency benefits of open trade that are completely separate from the well-understood avenues of increased specialization and competition, and which seem to be completely unacknowledged in the trade-theory literature.

This paper builds on some well-established traditions in industrial organization that have not been put to much use in trade theory. The "transactions-cost" approach to vertical integration has been espoused by Oliver E. Williamson (1971, 1989) and Benjamin Klein et al. (1978). Although it is by no means the only important theory of vertical integration [see Martin K. Perry (1989) for a survey], it has been shown to have a certain empirical explanatory power, as for example in Kirk Monteverde and David J. Teece (1982), Scott E. Masten (1984), and Paul L. Joskow (1987). Market-thickness effects also have a long history as an informal idea in law and economics, and much empirical evidence on their importance has been documented.[10] The incentive effects of different ownership structures in the context of specific investments and incomplete contracts are studied in Sanford J. Grossman and Oliver D. Hart (1986), Hart and John H. Moore (1990), and Bolton and Whinston (1993). Vertical integration emerges in some cases as the best response to the incentive problem. In the international trade literature, Barbara J. Spencer and Ronald W. Jones (1991, 1992) study the effects of vertical integration on strategic trade policy, without endogenizing the vertical integration decision.

Despite the richness of the literature on which it draws, the model used here has a number of novel features. It provides a notion of the thickness of a market that is very different from existing formulations of the idea,[11] since it has nothing to do with a reduction in monopsony power due to a rise in the number of buyers,[12] is unrelated to search-theoretic conceptions of market thickening such as in Peter A. Diamond (1982) or Rachel E. Kranton (1996), and has no connection with familiar "pin-factory" arguments on rising specialization with a larger market.[13] In addition, the model suggests new interpretations for some existing empirical results in the area, such as the negative correlation between market density and vertical integration documented by Holmes (1995); the broader evidence on market thickness mentioned above; and the case study evidence on differences in industrial structure in otherwise similar environments. Further, the model allows for *endogenous* choice of the degree of asset specificity by input providers,[14] providing a feedback effect that has not previously been explored in empirical work (since asset specificity has usually been assumed exogenous).

Section I sets up the model; Section II studies the determination of prices on the independent market; Section III derives equilibrium in the case of symmetric firms, which tends to give

[9] Related questions are addressed by Daron Acemoglu and Andrew F. Newman (1997), who show how international openness can lead to a move toward arms-length employment relationships.

[10] For example, Stephen Craig Pirrong (1993) uses contract data to provide evidence that thick markets reduce transactions costs. Although his own interpretation does not involve transactions costs, Thomas J. Holmes' (1995) finding that market density is negatively correlated with vertical integration in U.S. manufacturing could be read in the same way.

[11] However, some inspiration has been taken here from the formulation used by Lester C. Telser (1981) to identify the advantages of organized futures markets.

[12] This contrasts with existing papers on the use of competition to solve a hold-up problem, such as Joseph Farrell and Nancy T. Gallini (1988).

[13] A lucid formulation appears in Holmes (1995), who makes it clear that the pin-factory hypothesis is really about trading off a higher fixed cost for a lower marginal cost, rather than about the pattern of ownership of assets, and thus not really about vertical integration per se.

[14] Jay Pil Choi and Sang-Seung Yi (1997) use a similar formulation of endogenous specialization decisions in a model of vertical equilibrium, to show that specialized technology can be used as a commitment device for vertical foreclosure.

corner solutions; Section IV studies the case in which the firms are different enough that interior solutions are possible (the case of "wide diversity"); and Section V considers some alternative approaches.

I. The Model

A. *A Heuristic Sketch*

Before getting into the details of the model, a verbal summary of its mechanism may be useful. Consider an industry with n USF-DSF pairs, in which each USF can, after incurring a noncontractible sunk cost, make at most one indivisible specialized input, and each DSF can use at most one. Focus for the sake of argument on the integration decision of buyer-supplier pair 1, taking as given the decisions of all other pairs. The key variable of the problem is, loosely speaking, the probability that USF_1 will be able to find an alternative interested buyer to use as a threat point in its dealings with DSF_1; call this probability the "outside option probability." The hold-up problem results from USF_1's fear, as it contemplates making its sunk investment, that its outside option probability may be low.

The crux of the model is the following principle, which we might call the "market-thickness principle": *USF_1 is more likely to be able to find an alternative interested buyer to use as a threat point, the more unintegrated firms there are among USF-DSF pairs 2 through n.* If this principle is established, then it is clear that the main conclusion follows very quickly: The more unintegrated firms there are among USF-DSF pairs 2 through n, the weaker will be the hold-up problem faced by pair 1, and so the more feasible it will be for USF_1 and DSF_1 to remain unintegrated. This is the strategic-complements property that is at the heart of the paper.

There are, in general, many reasons this "market-thickness principle" may arise, but in this model it results from strategic specialization decisions made by the suppliers. Each nonintegrated supplier, say USF_j, chooses in equilibrium to produce an input that is less than completely specialized toward its intended buyer, in order to protect itself from holdup. In doing so, it enhances the probability of finding an outside option for itself, but it also sacrifices some of the effectiveness that would come from optimally fine-tuning its input to the needs of its intended buyer. Thus, its buyer, DSF_j, is more likely than an integrated firm to covet USF_1's input *ex post,* and the more of these unintegrated firms there are, the better are USF_1's chances of finding one who is interested. This is the mechanism that yields the market-thickness principle.

However, one more element is needed to complete the story: uncertainty about cost, quality, or technology. Each input is to some degree specialized to its intended user, so in order for buyer j to covet input i, it is necessary for input i to be superior overall to input j. Since it is not possible for *every* input to be superior overall to some other input, there must be an input that is not coveted, and whose supplier is therefore stuck without an outside option. If it had been known *ex ante* who that unfortunate supplier would be, that supplier would not have produced. *Ex ante* uncertainty about the quality of each input is what allows each supplier to hope to have an attractive outside option, while at the same time everyone understands that at least one supplier will have no such option.[15]

In short, technological uncertainty implies the *possibility* of an outside option for USF_1 arising among the other firms in the industry; the presence of the specialization decision then implies that this outside option is more likely to come from nonintegrated firms. These two features, both pervasive in business procurement in practice as discussed below, together give us the market-thickness principle, which in turn implies that USF_1 and DSF_1 are more likely to remain unintegrated, the more unintegrated firms there are among the others. Now, onto the formal details of the model.

[15] A referee has pointed out that it is possible to tell a story of a market-thickness principle in a model with no technological uncertainty in which a dissatisfied USF must search for an alternative transactions partner. However, although it is possible, it is not straightforward to construct such a model in which any DSF_j would be willing to purchase input $1, j \neq 1$, when each input is to some degree specialized to one downstream user; a detailed discussion of the necessary assumptions is available from the author on request.

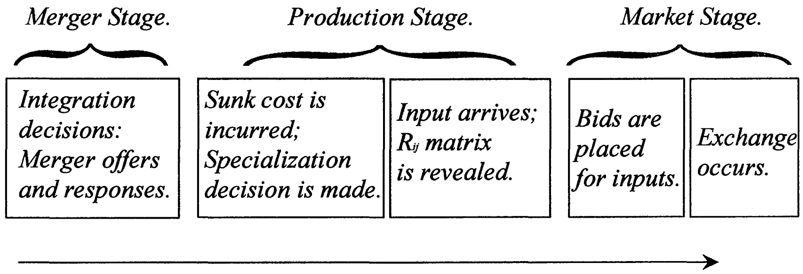

FIGURE 1. THE SEQUENCE OF EVENTS

B. *The Model in Detail*

First we describe the closed-economy version of the model; the open-economy version will then be straightforward. Consider an industrial sector composed of n DSF's producing differentiated final goods and n USF's,[16] all owned initially by distinct, risk-neutral, profit-maximizing agents with zero discount rates. We assume that entry into this sector is prohibitively costly both for USF's and for DSF's. The model will follow three stages, as laid out in Figure 1: A Merger Stage, a Production Stage, and a Market Stage. It is most convenient to discuss the Production Stage first.

Each DSF can reduce its fixed costs to some degree by procuring a specialized input.[17] These inputs can be tailor-made for the firm by the USF's, who require $K > 0$ units of labor to design and produce one unit of specialized input. This process takes two periods: The cost is incurred, irreversibly, in the first period of the Production Stage, and the output is obtained in the second period of the Production Stage. Each DSF can make use of at most one unit of specialized input, and each USF can produce only one unit.

Because of the lag between the costs and the output, the USF needs some reassurance that it will be paid remuneratively. To focus on the choice of organizational form, we assume that third-party verification problems preclude the possibility of purely contractual solutions [for an analysis of incomplete contracts in a similar setting, see McLaren (1999)]. This leaves two possible solutions. The first is the "integrated solution," in which the two partners form a merger; this would give rise to internal "governance" costs,[18] denoted by L, a positive constant.[19] Under the second solution, the USF simply produces the input and brings it to the open market, hoping to fetch a high enough price *ex post* to recoup its costs. This we will

[16] The unbalanced case, with different numbers of USF's and DSF's, is substantially more difficult, and thus is not treated in this paper. It is conjectured that a similar story would emerge, however, if it were. A detailed discussion is available from the author on request.

[17] Confining the discussion to fixed costs allows us to ignore the final goods market altogether. It would be natural to allow the inputs to affect marginal costs as well, but the resulting price effects would be a tremendous source of additional complication, and are not necessary to get to the main points of the paper. Further, it would open up the possibility of integration for the purpose of vertical foreclosure, a motive very different from the transactions-cost motive that is the focus here. This is the subject of Hart and Jean Tirole (1990), Janusz A. Ordover et al. (1990), Choi and Yi (1997), and, in the international context, Spencer and Jones (1991). Alternatively, we could assume that inputs affect marginal costs and that demand for the different final goods is separable, so that each DSF is effectively a monopolist on that market.

[18] Actually, any cost to integration would suffice for the argument of the paper, and there are many from which to choose. In practice, costs of negotiating a merger can be substantial, for example; Gordon H. Hanson (1995) shows that in some settings (such as the Mexican apparel industry) vertical integration can be costly because it requires giving up opportunities to diversify risk.

[19] Governance costs, or more broadly, managerial incentive costs of integration, are widely discussed in the economics literature, and nothing new will be said about them here. See Williamson (1971, 1989) for extensive treatments; Guillermo A. Calvo and Stanislaw Wellisz (1978), Michael H. Riordan (1990), and Jacques Crémer (1996) for formal models; and Grossman and Hart (1986) and Hart and Moore (1990) for treatments including this sort of incentive effect as part of a more general class.

call the "unintegrated" or "arm's-length" solution, the use of an "independent supplier," or simply the "market" solution.

Decisions on vertical integration are made in the Merger Stage at the beginning of the game. Suppose that both the DSF's and USF's are numbered from 1 to n and that before any other decisions have been made, each DSF_i has the option of making a take-it-or-leave-it merger offer to USF_i (in other words, a bid for purchase of the upstream asset). If DSF_i chooses not to make a merger offer, or if USF_i chooses not to accept it, no merger occurs, and USF_i decides whether or not to produce an input for DSF_i independently. Clearly, integration will occur if and only if the expected profit of the resulting integrated firm exceeds the sum of expected profits of the two unintegrated firms, taking the integration decisions of the other firms as given. These merger decisions by the various DSF-USF pairs occur simultaneously. We will denote the integrated firm resulting from the merger of USF_i and DSF_i as IF_i, and call the input made for DSF_i (whether by the integrated or arm's-length method) input i.

If integration occurs, the merged entity then incurs the sunk cost K, and designs and produces the input using the expected-profit-maximizing choice of technology. If integration does not occur, the two partners may meet and form an understanding *ex ante,* perhaps through a verbal agreement, but there is no commitment on either side. The unintegrated USF decides whether or not to proceed; if it proceeds, in the first period of the Production Stage it incurs the fixed cost K and chooses the technology strategy to follow; it then receives the output and accepts bids on it during the Market Stage. The input is then sold to the high bidder, ending the game.

There are two technology strategies available in designing an input: a strategy of "maximal specialization" and a strategy of "flexibility." In the maximal specialization strategy, the input is designed in such close accordance with the peculiarities of the production process of the DSF in question that it would be useless for any other purpose. The advantage of doing so is that this strategy gives the largest possible reduction in fixed costs to that user. Denote the cost reduction offered by the input designed for DSF_i, when used by DSF_j, as R_{ij}. Then, under a strategy of maximal specialization, $R_{ij} = 0$ if $i \neq j$. We normalize R_{ii} in this case to unity.

On the other hand, under the strategy of flexibility, the design process allows more room for the input to be compatible with other systems; since those other systems are likely to be less familiar to the USF, its uses with those systems are more likely to have a serendipitous nature than the gains from the specialized technology strategy. An input produced with flexible technology could take either of two forms. It could be an "*effective*" input, in which case it will give e units of cost reduction to its intended user, and e' units to any other user; or it could be a "*dud,*" in which case it will give d units of cost reduction to its intended user, and d' units to any other user. Thus, in this case the R_{ij}'s are random variables whose values are realized only when the input is ready,[20] with R_{ii} and R_{ij} ($i \neq j$) equal either to e and e' respectively, or d and d' respectively. Assume:

$$1 > e > e' > 0 \qquad \text{and} \qquad 1 > d > d' > 0.$$

This inequality ensures that a flexibly produced input is less effective for its intended use than a maximally specialized input would have been; it is more effective in that use than in alternative uses; but it is not completely worthless in alternative uses.

These specialization decisions could be interpreted, for example, as choosing the degree of "site specificity"[21] or "design specificity,"[22] to

[20] The nonstochastic nature of the R_{ij}'s under maximal specialization is assumed for simplicity only. If they were random, a sufficient condition for all of the following results to hold is that the lower bound for R_{ii} under maximal specialization be no lower than e', and the upper bound for R_{ij} ($i \neq j$) under maximal specialization be no higher than d.

[21] This is specificity resulting from physical proximity. One example is the nearness of a coal-burning electric utility to the mine that supplies it (Joskow, 1987); an aerospace example is the proximity of the computerized lathe for boring nose cones to the assembly plant in which the cones will be used. The lathes are very costly to move once installed, and so their location is a key strategic decision for the supplier (Masten, 1984).

[22] This is specificity resulting from the design process per se. Examples abound. (i) A software designer may write a program tailored to a single user firm, as is the norm in Japan, or design it for the mass market as packaged software, as is the norm in the United States (Yasunori Baba et

use Williamsonian terms. An important consequence of the assumptions made so far is that for either technology strategy:

$$(1) \quad R_{ii} > R_{ij} \text{ with probability 1 for all } i, \quad \text{where } j \neq i.$$

Inequality (1) states that for either technology strategy, each input is to some degree specialized to its intended user, and implies that the *ex post* optimal allocation of resources assigns each input to its originally intended user. It is useful to summarize this property by stating that input i has a "comparative advantage" in use i.

Further, assume that $e' > d$, so that an effective input has an "absolute advantage" over a dud: An effective input would be more effective if used for a user for whom it was not designed, than would a dud that had been designed for that user, but because of condition (1), it will still be efficient for input i to be allocated to user i and for j to be allocated to user j. Define $\Delta \equiv e' - d > 0$ as the size of that absolute advantage. Finally, assume that if input i is produced flexibly, it will be effective with probability $\rho_i \in (0, 1)$, and that this probability is independent of the outcome of the other inputs. We might call ρ_i the "aptitude for flexibility" of USF_i. It will be a convenient parameter to vary in what follows.[23]

In short, under an arm's-length arrangement, a USF designs an input, choosing specialized or flexible technology; once it is ready, the USF brings it to the market and sells it; after that, the game ends.

In the case of the open economy, there will be two countries which will be identical in every way. There will thus be $2n$ firms; those numbered 1 through n will be in country I and the following n will be in country II. In order to focus on the vertical structure aspects of the situation and to make the point that the effects of openness in this model have nothing to do with well-understood effects through product-market competition, assume that the n final goods produced in each country are unattractive to consumers in the other, so that the final goods are effectively nontraded. Inputs, on the other hand, can be traded across the border at a cost of t. Thus, if $i \leq n$ and $j > n$, for an input i, $R_{ij} = \{d' - t\}$ if it is designed with flexible technology and turns out to be a dud; $R_{ij} = \{e' - t\}$ if it turns out to be effective; and $R_{ij} = -t$ if it is maximally specialized. Apart from these changes, the open-economy version of the model works in the same way as the closed-economy version.

II. *Ex Post* Price Determination

To solve the model, we work backward from the determination of prices and input allocations in the Market Stage. For the moment assume a closed economy.

Once the n inputs have been produced, the matrix of R_{ij} values becomes known publicly, and the various DSF's can send bids to the various input makers. Let b_{ij} denote the bid made by buyer i for input j (for the moment allowing for the possibility that either firm i or firm j is integrated; an integrated firm always has the option of selling its input or of placing a bid for another firm's input). The bids are made simultaneously and each represents a commitment to buy the stated input at the stated price, provided the seller accepts the bid. After the bids have been received, each seller chooses one bid to accept. It will be convenient to define the vector of winning bids by $P_i = \max_j\{b_{ji}\}$, which can also be called the vector of equilibrium prices. We assume free disposal, and so without loss of generality we restrict bids to be nonnegative. In addition, since there is no meaningful

al., 1995). (ii) Melton Truck lines provides customized shipping services for Butler Manufacturing, which assembles prefab buildings for Wal-Mart in Mexico. Melton redesigned its computer system to integrate it with Butler's system and provide a more effective service (Buxbaum, 1994). (iii) IBM in the 1970's redesigned its mainframe computer interfaces, improving their performance but also making it difficult for non-IBM hard drives to be used with them (Gerald Brock, 1989).

[23] In the working paper (McLaren, 1996), a more general specification with a continuous distribution for the R_{ij}'s is worked out in detail; the more general case is vastly more complicated, but provides all of the same broad results. Most significantly, the market-thickness effect, Proposition 5, still holds, but is much more difficult to derive.

difference between a bid of zero and no bid, we will without loss of generality require each potential buyer to place a bid of at least zero for each input (except for its own input, if it is an integrated firm).

We will be interested in subgame-perfect equilibria of this bidding game, in order to construct subgame-perfect equilibria of the full game. Naturally, in such an equilibrium only high bids will be accepted. It is very important to keep in mind that in equilibrium the winning bid for any input will always be a tie.[24,25] It is useful to call a bidder who is tied with the winning bid but who does not receive the input a "runner-up bidder;" in a sense, the price of each input is determined by its runner-up bidder.

Propositions 1 through 4 provide a characterization of the equilibrium prices. The first point to note about these equilibria is that their outcome is *ex post* efficient.

PROPOSITION 1: *In any subgame-perfect equilibrium of the bidding game, for any matrix of cost reductions R_{ij}, no IF sells its input, and each independently produced input is sold to its originally intended buyer.*

This follows directly from (1), and is proven in the Appendix. This result considerably simplifies the problem. Recalling that each buyer can use at most one input, it allows us to write the condition for equilibrium as the condition that for each i and j, buyer j prefers to buy the input designed for her at price P_j rather than outbid buyer i for input i:

$$R_{jj} - P_j \geq R_{ij} - P_i \text{ for all } i \neq j,^{26}$$

or equivalently:

$$(2) \quad P_i \geq \max_{j \neq i}\{\max(R_{ij} - R_{jj} + P_j, 0)\}.$$

Since it shows that integrated firms will not engage in any purchase or sale in the market stage, Proposition 1 also implies the following immediate corollary.

PROPOSITION 2: *In a subgame-perfect equilibrium of the full game, any integrated firm will choose the maximally specialized technology.*

Any other choice would reduce $E[R_{ii}]$ without having any other effect on IF_i's profits. We obtain a further characteristic of equilibrium by eliminating weakly dominated strategies from the strategy set, thus leaving only "perfect" equilibria. In the context of this bidding game, this set of strategies includes any strictly positive bid by any buyer i for any input j such that $b_{ij} \geq R_{ji}$. Focussing on equilibria satisfying this refinement immediately tells us that if good i is maximally specialized, $b_{ji} = 0$ for $j \neq i$, since $R_{ij} = 0$ for $j \neq i$. Thus, we have Proposition 3.

PROPOSITION 3: *The equilibrium price of any maximally specialized good in a perfect equilibrium is equal to zero. In particular, in any perfect equilibrium of the full game, the equilibrium price of any input produced by an integrated firm is equal to zero.*

It is therefore obvious that an unintegrated supplier would never choose the maximally specialized technology. As a consequence of Propositions 2 and 3, we see that an input is produced with flexible technology if and only if it is produced by an unintegrated supplier. There is thus an exact correspondence between ownership structure and technology choice.

Strictly speaking, there are a range of equilibria satisfying the restrictions we have imposed.[27] However, this is a technical nuisance irrelevant to the main question; we will focus

[24] Otherwise, the winning bidder would not be bidding optimally, since any winning bid strictly above the runner-up bid could be lowered and still win.

[25] We do not impose any tie-breaking rule on sellers, but (as is seen in Proposition 1) in equilibrium, these ties are always broken by selling the input to the tying bidder who wants it the most.

[26] If j is integrated, this condition is unchanged. The payoff from keeping input j is R_{jj}; the maximum possible payoff from selling it and buying another is $P_j - P_i + R_{ij}$. The latter must not exceed the former, and this is the stated inequality.

[27] For example, if there are two inputs and both have been produced flexibly and have turned out to be effective, then $[b_{11}, b_{12}, b_{21}, b_{22}] = [p, p, p, p]$ is an equilibrium for any $p \in [0, e']$. All of these equilibria are perfect, and indeed, withstand iterative weak dominance.

only on the lowest-price equilibrium, which, it can be shown, is the only equilibrium in which bidders do not make losing bids that they would strictly prefer to lose.[28] This gives the following simple and intuitively appealing characterization of prices.

PROPOSITION 4. *The lowest-price equilibrium is well defined, and is as follows. If the inputs are either all duds or all effective, their prices are all zero. If there are at least one effective input and at least one dud, the price of each effective input is Δ and the price of each dud is zero.*

This is straightforward to see. First, the proposed pricing is an equilibrium, as can be easily checked from (2). In the case in which all inputs are effective, (2) is satisfied trivially, since the right-hand side is just $e' - e < 0$ for all i. In other words, no input has an absolute advantage relative to any other, so there is never a runner-up bidder to push the price above zero. The case with all duds is parallel. The interesting case is the one in which i is effective and j is a dud, $i \neq j$. In that case, the right-hand side of (2) is $e' - d = \Delta$, so the inequality holds exactly. In other words, DSF_j covets input i because it is so much better than input j, and places a bid for it equal to the absolute advantage of i relative to j. This is the runner-up bid that forces DSF_i also to bid Δ for input i.

Second, the same logic shows that this is indeed the lowest-price equilibrium. In particular, once again, when i is effective and j is a dud, if P_i were at all below Δ, DSF_j would bid slightly more than P_i for input i to snatch it away from DSF_i, yielding a contradiction.

Thus, in equilibrium, an input has a positive price if and only if it has an absolute advantage relative to some other input, and its price is then given by the size of that absolute advantage. Recalling that (1) guarantees that input i is allocated to user i, we might summarize the bidding game by suggesting that *comparative advantage determines the allocation of inputs, but absolute advantage determines the distribution of income.*[29]

By parallel reasoning, it is easy to see that the equilibrium in the case of an open economy is as follows. If $\Delta \leq t$, then in each economy the prices are what they would have been if the economy were closed. If $\Delta > t$, then: (i) All duds have a price of zero; (ii) If all inputs in both countries are effective, all prices are zero; (iii) An effective input in a country with at least one dud has a price of Δ; and (iv) An effective input in a country with only effective inputs has a price of $(\Delta - t)$ if there is at least one dud in the other country.

Now we can discuss the equilibria of the full model. We do this under two contrasting assumptions about the way the aptitude for flexibility differs across firms; first, the assumption that it does not vary at all (the symmetric case), and then the assumption that it varies greatly, in a sense to be made precise later (the case of "wide diversity").

III. Industry Equilibrium: The Symmetric Case

Suppose that ρ_i takes on the same value for all i, and denote this common value by ρ. Assume that $\rho\Delta > K$. An equilibrium can be constructed by working backward from the bidding game. For the moment assume a closed economy.

It has already been noted that any input produced by an integrated firm will be made with the maximally specialized technology strategy, and any input produced by an unintegrated firm will be made with flexible technology. Let $\mathcal{F}$ denote the set of USF's using flexible technology, and also the set of DSF's using independent suppliers. For any finite set S, let $N(S)$ denote the number of elements of S. Then for any nonintegrated firm i, it is clear that we can write the expected price of input i as a function

[28] See the working paper (McLaren, 1996) for details. This equilibrium is a priori the most plausible, but it should be noted that the same broad properties of the model can also be derived from other assumptions about price determination; see Section 6 of the working paper for examples. The low-price equilibrium used here is closely related to the "cautious" equilibrium concept of Dirk Bergemann and Juuso Välimäki (1996), which achieves the same goal in a different setting.

[29] In the general model with arbitrary distributions of the R_{ij}'s, a similar conclusion holds in a much more complicated form. In that model, the price of each input is determined by the *sum* of absolute advantages, cumulated along a *chain* of runner-up bidders. See McLaren (1996).

μ of ρ and $N(\mathcal{F})$. By virtue of Proposition 4, this takes the form:

$$\mu(\rho, N(\mathcal{F})) \equiv \rho[1-\rho^{N(\mathcal{F})-1}]\Delta,$$

since an input produced by a nonintegrated firm will have a price of Δ if it is effective and there is at least one dud, and zero otherwise. The dependence of μ on $N(\mathcal{F})$ is the sense in which the thickness of the independent market for inputs matters. Thus, we have the following proposition.

PROPOSITION 5: *The function* μ *is increasing in* $N(\mathcal{F})$.

This is the key to the argument of the paper. It may seem curious that a rise in $N(\mathcal{F})$, effectively the addition of one buyer and one seller to the open market, should lead to a rise in the expected prices of the various inputs. The explanation is that the price of an input is determined by the runner-up bid. Adding one more independent buyer and seller may either result in a new, higher runner-up bid for some incumbent input, or have no effect. There is no way it can lower the price of an input. To put the point in the terms of Section I, subsection A, the additional buyer/seller pair raises the outside option probability for every incumbent seller.[30]

An unintegrated USF_i will produce an input for DSF_i provided that it expects to receive a high enough price *ex post* to recoup its sunk costs, or in other words, provided that $\mu(\rho, N(\mathcal{F})) \geq \text{K}$. Since μ is increasing in $N(\mathcal{F})$, for a given value of ρ, this will clearly be true provided that $N(\mathcal{F})$ exceeds some threshold $\bar{n}$, defined by $\bar{n} = \min\{m | \mu(\rho, m) \geq K\}$. Thus, if, at the beginning of the game, $(\bar{n} - 1)$ or more other firms are expected to use arm's-length arrangements, it will be feasible for DSF_i to use an arm's-length arrangement as well. Otherwise, the only procurement option will be integration.[31]

If the two firms integrate, the net cost reduction will be $R_{ii} - L - K = 1 - L - K$ because the integrated entity will use the maximally specialized technology. The expected net cost reduction from arm's-length trade will be $\rho e + (1 - \rho)d - K$. There is clearly a trade-off between the two: The integrated solution allows for the greatest technological cost reduction (since e, $d < 1$), but imposes additional governance costs L. Since integration is always an option, if the former outweighs the latter, there is nothing to discuss: We will always observe integration. The problem becomes interesting only if this is not so, and so we assume the following.

ASSUMPTION 1:

$$1 - \rho e - (1 - \rho)d < L.$$

Thus, if it is feasible, the surplus from arm's-length trade will always exceed the surplus from integration, and an arm's-length arrangement will be the outcome of *ex ante* negotiations.

We can now speak of a Nash equilibrium in vertical structure. For any pair of firms i, if $\bar{n} - 1$ other pairs are expected to use an arm's-length arrangement, i will do so as well; but if fewer than $\bar{n} - 1$ are expected to integrate, i will integrate. It is immediate that this implies that the only possible equilibria are $N(\mathcal{F}) = 0$ and $N(\mathcal{F}) = n$: complete integration of the sector and universal use of independent suppliers.[32] Thus we have Proposition 6.

[30] It should also be emphasized that the effect driving Proposition 5 is *not* the erosion of the DSF's oligopsony power by enhanced competition, since the price vector in question can be derived as the (*ex post,* or spot) Walrasian equilibrium of the input market; hence, there is no meaningful monopsony power present. I thank Raquel Fernández for clarifying my thinking on this.

[31] The importance of "serendipity," in the form of *ex ante* uncertainty about the R_{ij}'s, should by now be clear (subject to the qualifications of footnote 15). If, for a given choice of technology, we removed the uncertainty and replaced each of the R_{ij}'s with its *ex ante* mean [so that $R_{ii} = \rho e + (1 - \rho)d \equiv A$ and $R_{ij} = \rho e' + (1 - \rho)d' \equiv B$ for flexible firms], then no flexible input would offer an absolute advantage in any alternative use (since $A > B$), and so no flexibly produced input would ever have a positive price. In this sense, *uncertainty about the outcome of technological development is what makes nonintegrated production possible.*

[32] Throughout, this paper ignores mixed-strategy equilibria, which clearly will exist when the two extreme pure-strategy equilibria exist. I thank Curtis Eaton for pointing this out.

PROPOSITION 6: *In a small closed economy ($n < \bar{n}$) with symmetric firms, the only equilibrium is complete vertical integration. In a large economy ($n \geq \bar{n}$), there are two equilibria: Complete integration and universal use of independent suppliers.*

This highlights a point about the transactions-cost approach that does not appear to be widely acknowledged: It implies a kind of strategic complementarity in integration decisions. A larger number of firms using independent supply implies a wider use of flexible technology, hence a thicker secondary market, and thus makes it more attractive for any given firm to use independent supply. An immediate consequence is that two otherwise identical economies in isolation from each other can evolve completely different industrial systems, one strictly more efficient than the other. This outcome bears a resemblance to descriptions of national differences in sourcing strategies and particularly the contrast between the highly integrated "fordist" model of Western economies and the striking predominance of outsourcing in Japanese industry as compared to other economies, which many observers appear to regard as an inherently more efficient sourcing system [for example, *The Economist* (1991), Gertler (1991), and Nishiguchi (1994)]. In addition, it carries with it the implication that despite this inefficiency of the integrated outcome, no single firm in the vertically integrated economy would wish to switch procurement methods: The input market would be too thin for it to be practical.

The open-economy version of this model is then straightforward to analyze. We must now write the unintegrated USF's expected revenue as $\mu(\rho, t, N(\mathcal{F}), N(\mathcal{F}'))$, where $\mathcal{F}'$ is the set of unintegrated firms in the other country, to take account of the fact that R_{ij} is a decreasing function of t if $i \leq n$ and $j > n$ or vice versa:

$$\mu(\rho, t, N(\mathcal{F}), N(\mathcal{F}')) \equiv \rho\{[1-\rho^{N(\mathcal{F})-1}]\Delta + \rho^{N(\mathcal{F})-1}[1-\rho^{N(\mathcal{F}')}](\max\{\Delta - t, 0\})\}.$$

We will call "globalization" a reduction in t, where the initial value will be taken as a sufficiently high value that in effect the two economies act as if closed (that is, $t \geq \Delta$). It is straightforward to see that μ is continuous and decreasing in t. If we define an economy as "small," "medium," or "large" depending on whether $n < \bar{n}/2$, $\bar{n}/2 < n < \bar{n}$, or $n > \bar{n}$, then it is clear that for two small economies, globalization will have no effect on vertical structure (since whatever value t takes, the only equilibrium will be integration). However, in the other two cases it can have significant effects.

PROPOSITION 7: *In the case of symmetric firms, a sufficient globalization between medium-sized countries will make the more efficient arm's-length equilibrium possible in both economies. It would not be possible in either economy without globalization.*

Clearly, if t falls by enough, the above reasoning for the closed-economy case will apply to the combined economies of the two countries. Thus, the finding that the only equilibria involved all firms acting in the same way applies as well.

PROPOSITION 8: *Whatever the size of the economies concerned, in the symmetric case, with a sufficient globalization any equilibrium will involve complete convergence of the vertical structure of the two economies.*

IV. Industry Equilibrium: The Case of Wide Diversity

The above symmetry assumption ought not to be taken too literally, since in practice it certainly is not true that every single business enterprise within an industry in a given country does business in exactly the same way. The reason is plausibly that there are some *ex ante* differences between firms, for example in their scope for flexibility. Thus, suppose that within each country, each firm has a different value for ρ_i. Let the firms in each country be ordered in descending order of ρ_i. Again, begin with the closed-economy case. If $\mathcal{F}$ is the set of flexibly produced inputs and if $i \in \mathcal{F}$, then we can write the expected revenue of unintegrated supplier i as:

$$\mu(\rho_i, \mathcal{F}) \equiv E[P_i].$$

This time, naturally, the *ex ante* revenue can differ between firms; and further, not only the number, but also the identities of the firms in the unintegrated set $\mathcal{F}$, will matter. Again, by virtue of Proposition 4, we can write the μ function simply:

$$\mu(\rho_i, \mathcal{F}) \equiv \rho_i[1 - \Pi_{j \in \mathcal{F} j \neq i}\{\rho_j\}]\Delta.$$

Not surprisingly, this implies that expected revenues will be higher for an unintegrated firm with a superior aptitude for flexibility, so that if $i, i' \in \mathcal{F}$ and $\rho_i > \rho_{i'}$, then:

$$\mu(\rho_i, \mathcal{F}) > \mu(\rho_{i'}, \mathcal{F}).$$

Assume that Assumption 1 holds for all i, with ρ_i in place of ρ. Because the payoff to a higher-ρ_i independent USF will be greater than that of a lower-ρ_i USF, in any Nash equilibrium pattern of vertical structure, if $\mathcal{F}$ is not empty, it must be composed of an unbroken sequence of firms from $i = 1$ up to, and including, a threshold firm, say $\tilde{n}$, with $\mu(\rho_{\tilde{n}}, \{1, \dots, \tilde{n}\}) \geq K$ but $\mu(\rho_{\tilde{n}+1}, \{1, \dots, \tilde{n}+1\}) \leq K$. If $\mu^*(i) \equiv \mu(\rho_i, \{1, \dots, i\})$ is a strictly decreasing function of i, there will be at most one such $\tilde{n}$, and hence at most one equilibrium with nonintegrated firms.[33] This will clearly be so if ρ_i falls sufficiently quickly in i; here we assume that it does.

In the open-economy case, USF$_i$'s expected revenue can be written $\mu(\rho_i, t, \{1, \cdots \tilde{n}\}, \{n + 1, \dots n + \tilde{n}'\})$, where $\tilde{n}'$ is the number of unintegrated firms in country II.[34] This is increasing in ρ_i, $\tilde{n}$, and $\tilde{n}'$, and decreasing in t. For any t and $\tilde{n}'$, we can find the value of $\tilde{n}$ consistent with equilibrium in country I. This gives a kind of country I "reaction function" (abusing the term somewhat, since each firm pair in country I acts independently). Since a rise in $\tilde{n}'$ shifts the function μ up, this "reaction function" necessarily slopes upward. Once again, strategic complementarity is in evidence in integration decisions. The same argument works for country II, and the two "reaction functions" can be combined to find the equilibrium number of independent suppliers $(\tilde{n}, \tilde{n}')$ in the two countries. This is demonstrated in Figure 2.

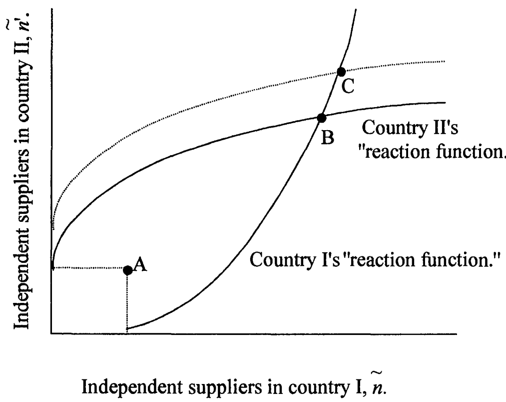

FIGURE 2. INTERNATIONAL EQUILIBRIUM UNDER WIDE DIVERSITY

In drawing Figure 2, it has been assumed that ρ_i falls sufficiently quickly in i, in the sense that:

ASSUMPTION 2:

$$\mu(\rho_{i+1}; \{1, \dots, i+1\},$$
$$\{n+1, \dots, n+i'+1\}) \leq \mu(\rho_i; \{1, \dots, i\},$$
$$\{n+1, \dots, n+i'\})$$

for all $i, i' < n$.

In other words, if we add one nonintegrated firm to country II, we need add no more than one additional nonintegrated firm to country I in order to restore equilibrium in country I. This implies that country I's "reaction function" never has a slope exceeding unity. This assumption, together with the analogous one for country II, thus ensures that country I's "reaction function" as drawn in Figure 2 is the steeper of the two, and is thus equivalent to so-called "stability assumptions" of simple oligopoly models. It also implies that $\mu(\rho_i, \{1, \dots, i\}, \{n+1, \dots, \tilde{n}'\})$ is decreasing in i, so that for any $\tilde{n}'$, there is at most one positive value of $\tilde{n}$ consistent with equilibrium, implying that the "reaction functions" are single-valued. From here on, Assumption 2, and its equivalent for country II, will be assumed. This is what is meant by "wide diversity" between business firms.

[33] There is also, always, an equilibrium in which all firms are integrated. From here on in, we focus on the equilibrium with nonintegrated firms.

[34] Precisely, $\mu(\rho_i, t, \mathcal{F}, \mathcal{F}') \equiv \rho_i\{[1 - \Pi_{j \in \mathcal{F} j \neq i}\{\rho_j\}]\Delta + \Pi_{j \in \mathcal{F} j \neq i}\{\rho_j\}[1 - \Pi_{j \in \mathcal{F}'}\{\rho_j\}](\max\{\Delta - t, 0\})\}$.

Globalization unambiguously raises the incidence of independent supply in both countries, moving the world economy from point A to point B. This leads to a welfare improvement in both countries, because of the assumption that Assumption 1 holds for each firm. Finally, note that under these conditions there is a sense in which outsourcing practices are internationally "contagious." For example, if the legal environment in country II changes so that the difficulties of vertical integration rise (so that L goes up in country II), that will lead to a rise in that country's incidence of outsourcing for any given country I outcome. This can be represented as the broken curve in Figure 2, a shift of country II's "reaction function." But this of course stimulates a greater use of outsourcing in country I, and this reinforces the additional popularity of outsourcing in country II. Thus, both countries depend to a greater extent than before on independent suppliers, with the final outcome at point C.

It should be remembered that at no time does any trade occur between these two countries at all; nor is there an intersectoral reallocation in either country; nor is there a rationalization of production to take advantage of scale economies; nor is there any reduction in oligopoly power that pushes prices closer to marginal costs. All of the usual avenues for welfare benefits from openness have been closed off. Nonetheless, the process of globalization has had substantial real effects in both countries, by thickening markets, reducing opportunism problems, and making more efficient organizational form possible.

V. Concluding Remarks

Three concluding comments are in order. First, to allow for greater focus on the one effect under study (namely, market thickening from greater openness), the model above has been extremely simplified, but it should be emphasized that the results discussed above can be derived in a variety of models with far less restrictive assumptions. For example, it has already been pointed out that the two-state assumption on technological uncertainty is not necessary for any of the results, and is thus made purely for simplicity; and it should also be pointed out that instead of an auction setup, the same essential results can be derived in a bargaining model in which both buyers and supplier have some bargaining power. See McLaren (1996) for details. Further, the "technological specialization" decision can take many forms, including (as seen in footnote 21) simple location decisions.

Second, although it is hoped that this model does shed some light on actual industrial structure, it should be emphasized that it does focus narrowly on one set of issues, and thus is not close to being a complete theory of comparative industrial relations. Serious treatments of the Japan-U.S. comparisons, for example, such as Masahiko Aoki (1988), stress differences along a large number of dimensions, such as internal as well as external firm structure, and not merely the extent of outsourcing but the *style* of outsourcing. The latter issue has received much attention lately, as, for example, in the work of Curtis R. Taylor and Steven N. Wiggins (1997), who stress the incentive effects of repeated interactions between buyer and supplier. However, it is hoped that the market-thickness element stressed here can contribute one piece of the puzzle, and further that the ideas developed here can be applied to some of these other areas. For example, McLaren (1999) shows that market-thickness effects such as are developed here may be able to help in explaining international differences in the style of outsourcing, in addition to vertical structure per se as emphasized here.

Finally, it would be of interest to incorporate the effects captured here into a more serious treatment of international trade. In this paper, as has been indicated, all of the usual channels through which globalization has its effects have been removed. It would be desirable to see how they would interact with the market-thickness effects when they are allowed back in. For example, if trade does allow for some rationalization of an industry, it is possible that that could provide an indirect effect that reduces market thickening in one country, thus attenuating the effect of globalization on organizational form; and that by the same token *increases* market thickening in the other country, thus intensifying these effects there.[35]

[35] I am grateful to a referee for suggesting this line of inquiry.

Appendix: Proof of Proposition 1

PROPOSITION 1: *In any subgame-perfect equilibrium of the bidding game, for any matrix of cost reductions R_{ij}, no IF sells its input, and each independently produced input is sold to its originally intended buyer.*

PROOF:

Suppose that in some equilibrium this is not so. In that case, denote $z(i)$ as the input finally used by buyer i. In no Nash equilibrium will any buyer buy more than one input, or any input go unused, so the function z is invertible. Set $\mathcal{E} = \{i | z(i) \neq i\}$, and note that $z(\mathcal{E}) \equiv \{z(k) | k \in \mathcal{E}\} = \mathcal{E}$. If $j \in \mathcal{E}$, then buyer j chooses to purchase input $z(j)$ rather than j; if j is unintegrated, she could have purchased j for any bid above P_j, so we must have:

$$R_{jj} - P_j \leq R_{z(j)j} - P_{z(j)}.$$

If $j \in \mathcal{E}$ is integrated, she has sold input j for a price of P_j instead of using it herself, so:

$$R_{jj} \leq R_{z(j)j} - P_{z(j)} + P_j, \quad \text{or}$$

$$R_{jj} - P_j \leq R_{z(j)j} - P_{z(j)}.$$

Thus, we must have:

$$\Sigma_{j \in \mathcal{E}}[R_{jj} - P_j] \leq \Sigma_{j \in \mathcal{E}}[R_{z(j)j} - P_{z(j)}].$$

Since $\mathcal{E} = z(\mathcal{E})$, this implies:

$$\Sigma_{j \in \mathcal{E}}[R_{jj}] \leq \Sigma_{j \in \mathcal{E}}[R_{z(j)j}] = \Sigma_{j \in \mathcal{E}}[R_{jz(j)}],$$

where the last equality follows from the invertibility of z. From (1), this must be false.

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