Organizing the Global Value Chain: Online Appendix

Pol Antràs
Harvard University

Davin Chor
Singapore Management University

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Abstract

This online Appendix documents several detailed proofs from Section 3 of our manuscript "Organizing the Global Value Chain" that were omitted due to space constraints. It also contains the Appendix Tables 1-6 mentioned in the main text of the paper.

A The Benchmark Model with Ex-Ante Transfers

In Section 3.1.A of the paper, we argue that introducing ex-ante lump-sum transfers between the firm and the suppliers has very little impact on the main results of our paper. Because these ex-ante transfers have no effect on ex-post decisions made after agents are locked in by the contracts, investment levels continue to be characterized by equation (10) in our main text. The key implication of introducing ex-ante transfers is that the objective function of the firm is no longer their ex-post payoff (as in equation (11) of the paper), but rather the joint surplus created along the value chain, or

$$\pi_T = A^{1-\rho}\theta^\rho \left(\int_0^1 x\left(j\right)^\alpha dj \right)^{\rho/\alpha} - \int_0^1 cx\left(j\right) dj. \tag{A.1}$$

This might reflect, as in Antràs (2003) and Antràs and Helpman (2004), the fact that the firm has full bargaining power ex-ante, in the sense that it can make take-it-or-leave-it offers to suppliers that include an initial transfer to the firm. With a perfectly elastic supply of suppliers, each with an ex-ante outside option equal to 0, these ex-ante transfers would thus be set in a way that allows the firm to appropriate all the surplus created along the value chain. Alternatively, even when both the firm and suppliers have some ex-ante bargaining power (perhaps because the number of potential suppliers is limited), the fact that agents have access to a means to transfer utility ex-ante in a distortionary manner implies, by the Coase theorem, that the organization of production along the value chain (i.e., which stages get integrated and which get outsourced) will be decided efficiently, namely in a joint-profit maximizing manner.

Note from equation (6) in the main text that $cx\left(j\right) = \alpha\left(1-\beta\left(j\right)\right) r'\left(j\right)$ for all $j \in [0,1]$. Plugging this into (A.1), we have

$$\pi_T = r\left(1\right) - \alpha \int_0^1 \left(1-\beta\left(j\right)\right) r'\left(j\right) dj = \left(1-\alpha\right) r\left(1\right) + \alpha\pi_F,$$

where π_F are the profits accruing to the firm in the absence of ex-ante transfers, i.e., $\int_0^1 \beta\left(j\right) r'\left(j\right) dj$ in equation (11) in the main text.

We use equation (9) in the main text evaluated at $m = 1$ to compute $r(1)$. The partial derivative of π_T with respect to $\beta(m)$ can then be written as:

$$\frac{\partial \pi_T}{\partial \beta(m)} = \alpha\kappa\theta^{\frac{\rho}{1-\rho}} (1-\beta(m))^{\frac{\alpha}{1-\alpha}-1} \left\{ -\left[\int_0^1 (1-\beta(j))^{\frac{\alpha}{1-\alpha}} dj \right]^{\frac{\rho-\alpha}{\alpha(1-\rho)}} + \Phi(m) \right\},$$

where $\Phi(m)$ is the same function as defined in equation (12) in the main text, i.e.,

$$\begin{aligned} \Phi(m) &= \left(1 - \frac{\beta(m)}{1-\alpha}\right) \left[\int_0^m (1-\beta(k))^{\frac{\alpha}{1-\alpha}} dk \right]^{\frac{\rho-\alpha}{\alpha(1-\rho)}} \\ &\quad - \frac{\rho-\alpha}{(1-\alpha)(1-\rho)} \int_m^1 \beta(j)(1-\beta(j))^{\frac{\alpha}{1-\alpha}} \left[\int_0^j (1-\beta(k))^{\frac{\alpha}{1-\alpha}} dk \right]^{\frac{\rho-\alpha}{\alpha(1-\rho)}-1} dj, \end{aligned}$$

and $\kappa \equiv A\frac{\rho}{\alpha}\left(\frac{1-\rho}{1-\alpha}\right)^{\frac{\rho-\alpha}{\alpha(1-\rho)}}\left(\frac{\rho}{c}\right)^{\frac{\rho}{1-\rho}}$.

Setting $\frac{\partial \pi_T}{\partial \beta(m)} = 0$, the (unconstrained) optimal bargaining share that would maximize profits for the firm is then given by

$$\beta_T^*(m) = \max\left\{ \beta^*(m) - \frac{(1-\alpha)\left[\int_0^1 (1-\beta(j))^{\frac{\alpha}{1-\alpha}} dj\right]^{\frac{\rho-\alpha}{\alpha(1-\rho)}}}{\left[\int_0^m (1-\beta(k))^{\frac{\alpha}{1-\alpha}} dk\right]^{\frac{\rho-\alpha}{\alpha(1-\rho)}}}, 0 \right\}$$

where $\beta^*(m)$ is the corresponding unconstrained optimal bargaining share in our Benchmark Model, given explicitly by equation (13) in the main text. Note that in the presence of ex-ante transfers, the unconstrained optimal bargaining share $\beta_T^*(m)$ accruing to the firm is necessarily (weakly) lower than in the case without transfers. The intuition is simple: the rent extraction effect is no longer present and thus the firm has, other things equal, a higher incentive to allocate ex-post bargaining power to suppliers.

The key thing to note about the new negative term in $\beta_T^*(m)$ is that it is increasing in m when $\rho > \alpha$, while it is decreasing in m for $\rho < \alpha$, as is the case with $\beta^*(m)$ (shown in the main text). It follows then that Lemma 1, which we reproduce below, continues to hold in the setup with ex-ante transfers.

Lemma A.1 The (unconstrained) optimal bargaining share $\beta_T^*(m)$ is a weakly increasing function of m in the complements case ($\rho > \alpha$) while it is a weakly decreasing function of m in the substitutes case ($\rho < \alpha$).

In sum, Lemma A.1 confirms that whether the incentive for the firm to retain a larger surplus share increases or decreases along the value chain continues to crucially depend on the relative size of the parameters ρ and α, which we view as the central result of our paper.

The key difference with our Benchmark Model without ex-ante transfers relates to the *level* of the share $\beta_T^*(m)$. In particular, note that when $m \to 1$, we now have $\beta_T^*(m) = 0$, and the firm will necessarily find it optimal to outsource the last stages of production regardless of the other parameter values. This in turn implies that in the sequential complements case ($\rho > \alpha$), the firm cannot possibly find it optimal to integrate *any* production stage (since $\beta_T^*(m)$ is increasing in m). Conversely, when $\rho < \alpha$, it continues to be the case that $\beta_T^*(0) = 1$, as the additional negative term in $\beta_T^*(m)$ goes to 0 when $m \to 0$. In sum, in the sequential substitutes case, integration of upstream suppliers continues to be attractive because it serves a useful role in providing incentives to invest for downstream suppliers, as in our Benchmark Model. Note also that the proof by contradiction used in Proposition 2 in the main text can be readily adapted to show the uniqueness of the cutoff stage, since that proof carries through with the new profit function $\pi_T = (1-\alpha)r(1) + \alpha\pi_F$.

B Linkages Across Bargaining Rounds

In this Appendix, we include the details related to the variant of our model outlined in Section 3.1.B, in which we allow suppliers to internalize the effect of their investment levels and their negotiations with the firm on the subsequent negotiations between the firm and downstream suppliers. As argued in the paper, it now becomes important to specify precisely the implications of an (off-the-equilibrium path) decision by a supplier to refuse to deliver its input to the firm. The simplest case to study is one in which once the production process incorporates an incompatible input (say because a supplier refused to trade with the firm), all downstream inputs are then necessarily incompatible as well, and thus their marginal product is zero and firm revenue remains at $r(m)$ if the deviation happened at stage m. (We will briefly discuss alternative assumptions below.)

For reasons that will become apparent, it is necessary to develop our results within a discrete-player version of the game between the firm and the suppliers, in which each of $M > 0$ suppliers controls a measure $1/M$ of production stages. We will later run the limit as $M \to \infty$ to compare our results with those in the Benchmark Model in our paper. Assuming that each supplier sets a common investment level for all the production stages under its control (remember that, leaving aside the sequentiality of stages, the production function is symmetric in investments), revenue generated up to supplier $K < M$ is given by

$$R(K) = A^{1-\rho}\theta^{\rho}\left[\sum_{k=1}^{K}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho}{\alpha}},$$

if all the suppliers upstream of K have delivered compatible inputs before supplier K makes its own investment decision (thus respecting the natural sequencing of the stages). We use uppercase letters to denote variables in the discrete-player case, to distinguish them from the lowercase letters for the continuum case.

We solve the game by backward induction. Consider the negotiations between the firm and the most downstream supplier, M. Provided that all upstream suppliers have delivered compatible inputs, the value of production generated before supplier M's input is given by $R(M-1)$. If supplier M then provides a compatible input, the value of production will increase to $R(M)$. Following the reasoning in our paper, the ex-post payoff for supplier M will then be

$$P_S(M) = (1-\beta(M))(R(M) - R(M-1)), \tag{B.1}$$

where $\beta(M) = \beta_O$ in the case of outsourcing and $\beta(M) = \beta_V > \beta_O$ in the case of integration. The firm then obtains a payoff equal to $\beta(M)(R(M) - R(M-1))$ in that stage of production.

Moving to the supplier immediately upstream from M, i.e., $M-1$, note that the value of production up to that point is $R(M-2)$ and will remain at that value if an incompatible input is produced. If that were to happen, not only would the incremental contribution $R(M-1) - R(M-2)$ be lost, but note that the firm would also lose its share of rents at stage M, which is $\beta(M)(R(M) - R(M-1))$. In sum, the *effective* incremental contribution of supplier $M-1$ to the joint payoff of the firm and supplier $M-1$ is given by

$$R(M-1) - R(M-2) + \beta(M)(R(M) - R(M-1))$$

and thus its ex-post payoff is:

$$\begin{aligned} P_S(M-1) &= (1-\beta(M-1))\left[R(M-1) - R(M-2) + \beta(M)(R(M) - R(M-1))\right] \\ &= (1-\beta(M-1))(R(M-1) - R(M-2)) + \beta(M)\frac{(1-\beta(M-1))}{(1-\beta(M))}P_S(M), \end{aligned}$$

where in the second line we have used equation (B.1).

Iterating this formula backwards, we then find that, as stated in the main text, the profits of a supplier $K \in \{1, \ldots, M-1, M\}$ are given by

$$\pi_S(K) = (1 - \beta(K)) \sum_{i=0}^{M-K} \mu(K, i) (R(K+i) - R(K+i-1)) - \frac{1}{M} c X(K), \tag{B.2}$$

where

$$\mu(K, i) = \begin{cases} 1 & \text{if} \quad i = 0 \\ \prod_{l=1}^{i} \beta(K+l) & \text{if} \quad i \geq 1 \end{cases}. \tag{B.3}$$

The key difference relative to our Benchmark Model is that the payoff to a given supplier in equation (B.2) is now not only a fraction $1 - \beta(K)$ of the supplier's own *direct* contribution $R(K) - R(K-1)$, but also incorporates a share $\mu(K, i)$ of the direct contribution of each supplier located i positions downstream from K, where $1 \leq i \leq M - K$. Note, however, that the share of supplier $K + i$'s direct contribution captured by K quickly falls in the distance between K and $K + i$ (see equation (B.3)).

In order to assess the implications of this alternative setup for the choice of investment, note that a first-order Taylor approximation of the revenue function delivers

$$R(K+i) - R(K+i-1) \approx A^{1-\rho} \theta^{\rho} \frac{\rho}{\alpha} \left[\sum_{k=1}^{K+i-1} \frac{1}{M} X(k)^{\alpha} \right]^{\frac{\rho - \alpha}{\alpha}} \frac{1}{M} X(K+i)^{\alpha} \text{ for all } i \geq 0. \tag{B.4}$$

We next consider the first-order condition associated with the choice of investment by the supplier at position K. For the time being and to build intuition, consider the case in which upstream suppliers do not internalize the effect of their investments on the investment decision of downstream suppliers.

Despite this assumption (which we will relax below), the equilibrium investment choices of the current variant of the model would be expected to differ from those in our Benchmark Model because the payoff to supplier K is now a function of the direct contribution of all suppliers downstream from K, and these 'downstream' contributions are themselves a function of supplier K's investments. To be more precise, plugging (B.4) into (B.2) and taking the derivative with respect to $X(K)$, the first-order condition is given after some rearrangement by

$$\begin{aligned} \frac{c}{\rho A^{1-\rho} \theta^{\rho}} &= (1 - \beta(K)) \left[\sum_{k=1}^{K-1} \frac{1}{M} X(k)^{\alpha} \right]^{\frac{\rho - \alpha}{\alpha}} X(K)^{\alpha - 1} \\ &\quad + (1 - \beta(K)) \mathbf{1}(K < M) \sum_{i=1}^{M-K} \mu(K, i) \frac{\rho - \alpha}{\alpha} \left[\sum_{k=1}^{K+i-1} \frac{1}{M} X(k)^{\alpha} \right]^{\frac{\rho - 2\alpha}{\alpha}} \frac{1}{M} X(K)^{\alpha - 1} X(K+i)^{\alpha}, \end{aligned}$$

where $\mathbf{1}(K < M)$ is an indicator function equal to 1 if $K < M$, and equal to 0 otherwise. The first term reflects the effect of supplier K's investment on its own dirct contribution, and is the key term highlighted in the Benchmark Model. The second term captures the effects of supplier K's investments on the direct contributions of downstream suppliers $K' > K$.

In order to formally study the convergence of these terms as $M \to \infty$, it is convenient to study the choice of investment by a supplier with a fraction m of suppliers upstream from him or her, that is the supplier in position $K = mM$. The first-order condition above then becomes

$$\frac{c}{\rho A^{1-\rho}\theta^{\rho}} = (1-\beta(mM))\left[\sum_{k=1}^{mM-1}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho-\alpha}{\alpha}} X(mM)^{\alpha-1}$$
$$+ (1-\beta(mM))\mathbf{1}(m<1)\sum_{i=1}^{M-mM}\mu(mM,i)\frac{\rho-\alpha}{\alpha}\left[\sum_{k=1}^{mM+i-1}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho-2\alpha}{\alpha}}\frac{1}{M}X(mM)^{\alpha-1}X(mM+i)^{\alpha}.$$

Note, however, that the term

$$\left[\sum_{k=1}^{mM-1}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho-\alpha}{\alpha}} \tag{B.5}$$

converges to the Riemann integral

$$\left[\int_0^m x(j)^{\alpha}dj\right]^{\frac{\rho-\alpha}{\alpha}} = \left(\frac{r(m)}{A^{1-\rho}\theta^{\rho}}\right)^{\frac{\rho-\alpha}{\rho}}$$

when $M \to \infty$. Let us assume that when investing to produce a compatible input, the choice of investment by suppliers, $X(k)$, is uniformly bounded, so that $0 < \underline{C} \leq X(k) \leq \overline{C}$ for all k. We will confirm below that this is a feature of the equilbrium (both in the Benchmark Model as well as in this extended one), but we impose this assumption upfront to simplify the exposition. It then follows that $r(m)^{(\rho-\alpha)/\alpha}$ is bounded for given $m > 0$, and the same will be true for the term in (B.5) as $M \to \infty$.[1]

As for the terms

$$\left[\sum_{k=1}^{mM+i-1}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho-2\alpha}{\alpha}} \tag{B.6}$$

that appear in the second line of the first-order condition, we need to establish that there is a uniform bound for these as i runs from 1 to $M - mM$. If $\rho > 2\alpha$, this upper bound is given by $r(1)^{(\rho-2\alpha)/\alpha}$. On the other hand, if $\rho < 2\alpha$, then $r(m)^{(\rho-2\alpha)/\alpha}$ provides the necessary bound. (Recall here that m is fixed as we are considering m's first-order condition.) Thus, each of the terms in (B.6) is uniformly bounded from above as $M \to \infty$. Let C_1 denote this bound.

We finally note that $\sum_{i=1}^{M-mM}\mu(mM,i)$ also remains uniformly bounded as $M \to \infty$. To see this, note that $\beta(k) \leq \beta_V$ for k, so that

$$0 \leq \lim_{M\to\infty}\sum_{i=1}^{M-mM}\mu(mM,i) \leq \lim_{M\to\infty}\sum_{i=1}^{M}\beta_V = \frac{\beta_V}{1-\beta_V} \equiv B.$$

With these results in hand, note that with some abuse of notation, the first line of the first-order condition converges as $M \to \infty$ to

$$(1-\beta(m))\left(\frac{r(m)}{A^{1-\rho}\theta^{\rho}}\right)^{\frac{\rho-\alpha}{\rho}} x(m)^{\alpha-1},$$

[1] For the case of the initial supplier ($m = 0$), these terms are irrelevant for that supplier's investment, since no value has been generated up to that supplier.

while in absolute terms, the second line satisfies

$$\begin{aligned}
& (1-\beta(mM))\mathbf{1}(m<1)\sum_{i=1}^{M-mM}\mu(mM,i)\left|\frac{\rho-\alpha}{\alpha}\right|\left[\sum_{k=1}^{mM+i-1}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho-2\alpha}{\alpha}}\frac{1}{M}X(mM)^{\alpha-1}X(mM+i)^{\alpha} \\
\leq\;& (1-\beta(mM))\left|\frac{\rho-\alpha}{\alpha}\right|\sum_{i=1}^{M-mM}\mu(mM,i)\,C_1\frac{1}{M}\underline{C}^{\alpha-1}\overline{C}^{\alpha} \\
\leq\;& (1-\beta(mM))\left|\frac{\rho-\alpha}{\alpha}\right|C_1\frac{1}{M}\underline{C}^{\alpha-1}\overline{C}^{\alpha}\sum_{i=1}^{M-mM}\mu(mM,i) \\
\leq\;& (1-\beta(mM))\left|\frac{\rho-\alpha}{\alpha}\right|C_1\frac{1}{M}\underline{C}^{\alpha-1}\overline{C}^{\alpha}B,
\end{aligned}$$

and the latter expression tends to 0 as $M\to\infty$. In sum, the second term in the first-order condition becomes negligible when $M\to\infty$, and thus the first-order condition collapses to

$$c=\rho\left(A^{1-\rho}\theta^{\rho}\right)^{\frac{\alpha}{\rho}}(1-\beta(m))\,r(m)^{\frac{\rho-\alpha}{\rho}}\,x(m)^{\alpha-1},$$

as in our Benchmark Model.

So far we have ignored the fact that suppliers might internalize the effects of their investments on the investment decisions of downstream suppliers. We ignored this as well in the Benchmark Model, but that was without loss of generality, because in that model a supplier K's payoff was only a function of the investments of upstream suppliers, which were already fixed by the time the K-th input was incorporated into production. In the current game, investments by downstream suppliers are also relevant for payoffs, so this further complicates the first-order condition. When allowing for these effects, the first-order condition for $X(K)$ now becomes

$$\begin{aligned}
\frac{c}{\rho A^{1-\rho}\theta^{\rho}} &= (1-\beta(K))\left[\sum_{k=1}^{K-1}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho-\alpha}{\alpha}}X(K)^{\alpha-1} \\
&+\;(1-\beta(K))\mathbf{1}(K<M)\left\{\sum_{i=1}^{M-K}\mu(K,i)\left[\sum_{k=1}^{K+i-1}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho-\alpha}{\alpha}}X(K+i)^{\alpha-1}\frac{\partial X(K+i)}{\partial X(K)}\right. \\
&+\left.\sum_{i=1}^{M-K}\mu(K,i)\frac{\rho-\alpha}{\alpha}\left[\sum_{k=1}^{K+i-1}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho-2\alpha}{\alpha}}\left(\sum_{l=0}^{i-1}\frac{1}{M}\frac{\partial X(K+l)}{\partial X(K)}X(K+l)^{\alpha-1}\right)X(K+i)^{\alpha}\right\}.
\end{aligned}$$

Using analogous arguments to those above, it is easy to show that provided that as $M\to\infty$, $\frac{\partial X(K+i)}{\partial X(K)}\to 0$ for any $K<M$ and any i with $0<i<M-K$, then these extra terms will again vanish and the first-order condition of this extended game will again converge to that in our Benchmark Model. Quite intuitively, this new force will only matter when upstream investments have a measurable impact on downstream investments.

It thus suffices to show that indeed for any K and any $i=1,...,K-1$, $\frac{\partial X(K)}{\partial X(K-i)}\to 0$ as $M\to\infty$. For this, consider the objective function of supplier K in equation (B.2). We will simply show that, as $M\to\infty$, the effect of any upstream investment $X(K-i)$ on this payoff is negligible, thus implying that the choice of investment $X(K)$ obtained by maximizing $\pi_S(K)$ in (B.2) cannot possibly be measurably affected by these upstream investments. More specifically, simple differentiation of (B.2) after plugging in (B.4) delivers

$$\begin{aligned}\left|\frac{\partial \pi_S(K)}{\partial X(K-i)}\right| &= (1-\beta(K))\sum_{i=0}^{M-K}\mu(K,i)\left(\rho A^{1-\rho}\theta^{\rho}\left|\frac{\rho-\alpha}{\alpha}\right|\left[\sum_{k=1}^{K+i-1}\frac{1}{M}X(k)^{\alpha}\right]^{\frac{\rho-2\alpha}{\alpha}}X(K-i)^{\alpha-1}\frac{1}{M^2}X(K+i)^{\alpha}\right)\\ &\leq (1-\beta(K))\sum_{i=0}^{M-K}\mu(K,i)\left(\rho A^{1-\rho}\theta^{\rho}\left|\frac{\rho-\alpha}{\alpha}\right|C_1\frac{1}{M^2}\underline{C}^{\alpha-1}\overline{C}^{\alpha}\right)\\ &\leq (1-\beta(K))\rho A^{1-\rho}\theta^{\rho}\left|\frac{\rho-\alpha}{\alpha}\right|C_1\frac{1}{M^2}\underline{C}^{\alpha-1}\overline{C}^{\alpha}B,\end{aligned}$$

which clearly goes to 0 when $M \to \infty$ at a faster rate than c/M does. Consequently, we have $\frac{\partial X(K)}{\partial X(K-i)} \to 0$ as $M \to \infty$, and this completes the proof of the following result:

Proposition B.1 *The investment levels associated with this more general game that allows for linkages across bargaining stages delivers the same investment levels as our Benchmark Model when $M \to \infty$, i.e., when there is a continuum of suppliers*

As argued in the main text, because investment levels are identical to those in the Benchmark Model, the total surplus generated along the value chain will also remain unaltered. Hence, when ownership structure along the value chain is decided in a joint-profit maximizing manner, as in the model with ex-ante transfers outlined in Section A of this Appendix, the introduction of linkages across bargaining stages delivers the exact same predictions as the same model without these linkages.

In the absence of ex-ante transfers, the choice of ownership structure of this expanded model becomes significantly more complicated due to the fact that the ex-post rents obtained by the firm in a given stage are now lower than in the Benchmark Model, and more so the more upstream the supplier is. This is apparent from equation (B.2) above, which implies that the profits of the firm would be

$$\pi_F = R(M) - \sum_{k=1}^{M}\beta(k)\sum_{i=0}^{M-k}\mu(k,i)\left(R(k+i)-R(k+i-1)\right),$$

Other things equal, relative to our Benchmark Model, there is an additional incentive for the firm to integrate relatively upstream suppliers, regardless of the relative size of ρ and α, because of what in our paper we have termed the rent extraction effect. Unfortunately, a simple explicit formula for π_S and π_F cannot be obtained even in the limiting case $M \to \infty$, thus precluding an analytical characterization of ownership structure decisions along the value chain. We would hypothesize, however, that Proposition 2 in our paper would survive in the sequential substitutes case (since this new force should only reinforce the incentive to integrate upstream suppliers), while our results regarding the sequential complements case might become more nuanced in the absence of lump-sum transfers.

Our derivations above have relied on the strong assumption that once the production process incorporates an incompatible input, all downstream inputs are then necessarily incompatible as well. We have also worked out a variant of the game in which when a supplier refuses to deliver an input and that stage is completed with an incompatible input, the production process continues without implying that the marginal productivity of downstream investments is driven down to 0. Of course, such a deviation would still affect the subsequent negotiations between the firm and downstream suppliers because by providing an incompatible input, a supplier still affects the marginal productivity of downstream investments and thus affects the amount of surplus that the firm will obtain in subsequent negotiations. Foreseeing this, a supplier contemplating a deviation might insist on obtaining a share of its effective contribution, rather than a share of its direct contribution, as in our Benchmark Model. Without delving into the details, when solving for the payoffs of this variant of the game, we find that the ex-post payoff of a supplier K in the discrete-player case with M players can again be represented as

$$\pi_S(K) = (1-\beta(K)) \sum_{i=0}^{M-K} \tilde{\mu}(K,i)\left(R(K+i) - R(K+i-1)\right) - \frac{1}{M} cX(K),$$

and thus is a weighted sum of shares of direct contributions of all suppliers located downstream from K, where $1 \leq i \leq M-K$. The key difference is that the weights are no longer simply given by the expression in (B.3), but instead are now given by

$$\tilde{\mu}(K,i) = \sum_{j=0}^{M-K-i} (-1)^j \mu(K, i+j)\, a(i,j)$$

where $\mu(K,i)$ is given by (B.3) and

$$a(i,j) = \begin{cases} 1 & \text{if} \quad i = 0 \\ \displaystyle\sum_{k=0}^{j} a(i-1,k) & \text{if} \quad i > 0 \end{cases}.$$

An important difference between this solution and the one developed above is that even for $i = 0$ (i.e., even focusing on the direct contribution of supplier K), the share of surplus accruing to supplier K is no longer given by $1-\beta(K)$, but instead is given by

$$\begin{aligned} \tilde{\mu}(K,0) &= 1 + \sum_{j=1}^{M-K} (-1)^j \prod_{l=1}^{j} \beta(K+l) \\ &= 1 - \beta(K+1) + \beta(K+1)\beta(K+2) - \beta(K+1)\beta(K+2)\beta(K+3) + ..., \end{aligned}$$

and thus depends on all ownership decisions downstream from K. As a result, even when the effect on $X(K)$ of supplier K obtaining a share of the direct contributions of downstream suppliers is negligible (as shown above in our simpler extended model), the investment levels will differ from those in the Benchmark Model. In particular, in that case $X(K)$ would effectively solve

$$(1-\beta(K))\left(1 + \sum_{j=1}^{M-K} (-1)^j \prod_{l=1}^{j} \beta(K+l)\right)\left(R(K) - R(K-1)\right) - \frac{1}{M} cX(K),$$

and would thus depend directly on all $\beta(K+i)$ with $0 \leq i \leq M-K$. Again, the fact that we cannot analytically characterize the convergence of this objective function when $M \to \infty$ precludes a straightforward comparison of the implications of this model with those of our Benchmark Model.

Appendix Table 1
Summary Statistics

Variable	10th	25th	Median	75th	90th	Mean	Std. Dev.
Share of Intrafirm trade (year=2000)	0.107	0.209	0.372	0.535	0.659	0.382	0.207
Share of Intrafirm trade (year=2005)	0.132	0.222	0.386	0.557	0.650	0.392	0.203
Share of Intrafirm trade (year=2010)	0.133	0.236	0.404	0.560	0.663	0.402	0.209
<u>Of Seller Industries</u>:							
DUse_TUse	0.265	0.456	0.646	0.798	0.885	0.614	0.228
DownMeasure	0.316	0.370	0.492	0.744	0.907	0.559	0.222
Final Use / Output	0	0.011	0.313	0.781	0.919	0.396	0.373
Skill Intensity, Log(s/l)	-1.723	-1.541	-1.306	-1.006	-0.766	-1.276	0.382
Physical Capital Intensity, Log(k/l)	3.875	4.244	4.747	5.263	6.091	4.835	0.825
Log(equipment k / l)	3.271	3.785	4.311	4.852	5.664	4.368	0.904
Log(plant k / l)	2.930	3.273	3.67	4.186	4.855	3.796	0.757
Materials intensity, Log(materials/l)	4.054	4.311	4.734	5.258	5.711	4.841	0.719
R&D intensity, Log(0.001+R&D/Sales)	-6.908	-6.908	-6.239	-4.300	-2.912	-5.436	1.764
Dispersion	1.636	1.744	1.844	1.988	2.16	1.882	0.224
Value-added / Value of shipments	0.355	0.435	0.511	0.594	0.645	0.509	0.116
Input "Importance"	0.0003	0.0009	0.002	0.003	0.0066	0.0034	0.0066
Intermediation	0.28	0.31	0.339	0.498	0.61	0.401	0.127
Own Contractibility	0	0	0	0.6	0.993	0.263	0.386
<u>Of Buyer Industries</u>:							
Import elasticity, ρ	3.154	4.900	7.695	10.468	18.465	10.217	11.117
Skill Intensity, Log(s/l)	-1.693	-1.485	-1.295	-1.034	-0.766	-1.260	0.348
Physical Capital Intensity, Log(k/l)	3.999	4.392	4.755	5.131	5.574	4.767	0.629
Log(equipment k / l)	3.410	3.873	4.318	4.686	5.142	4.284	0.702
Log(plant k / l)	3.054	3.365	3.676	4.042	4.533	3.746	0.570
Materials intensity, Log(materials/l)	4.212	4.533	4.861	5.221	5.643	4.900	0.579
R&D intensity, Log(0.001+R&D/Sales)	-6.904	-6.655	-5.675	-4.551	-3.328	-5.408	1.361
Dispersion	1.710	1.787	1.907	2.007	2.122	1.908	0.177
Buyer Contractibility	0	0.003	0.067	0.297	0.653	0.207	0.283

Notes: Tabulated based on the 253 IO2002 manufacturing industries in the regression sample. For details on the construction of the data variables, please see the Data Appendix.

Appendix Table 2
Correlations of Industry Variables with Downstreamness

	Correlation with:	
	DUse_TUse	DownMeasure
Of Seller Industries:		
Skill Intensity, Log(s/l)	-0.081	0.072
Physical Capital Intensity, Log(k/l)	-0.400***	-0.374***
Log(equipment k / l)	-0.413***	-0.418***
Log(plant k / l)	-0.347***	-0.272***
Materials intensity, Log(materials/l)	-0.209***	-0.142**
R&D intensity, Log(0.001+R&D/Sales)	-0.144**	-0.072
Dispersion	-0.225***	-0.072
Value-added / Value of shipments	0.177***	0.134**
Input "Importance"	-0.031	-0.095
Intermediation	0.317***	0.249***
Own Contractibility	-0.355***	-0.348***
Of Buyer Industries:		
Import elasticity, ρ	0.046	0.104*
Skill Intensity, Log(s/l)	-0.053	0.034
Physical Capital Intensity, Log(k/l)	-0.255***	-0.319***
Log(equipment k / l)	-0.284***	-0.364***
Log(plant k / l)	-0.174***	-0.204***
Materials intensity, Log(materials/l)	-0.112*	-0.193***
R&D intensity, Log(0.001+R&D/Sales)	-0.132**	-0.104*
Dispersion	-0.137**	-0.136**
Buyer Contractibility	-0.189***	-0.239***

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively. Calculated from the 253 IO2002 manufacturing industries in the regression sample.

Appendix Table 3
Downstreamness and the Intrafirm Import Share: Direct plus Final Use Share

	Dependent variable: Intrafirm Import Share							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Elas < Median	Elas >= Median	Weighted		Weighted
Log (s/l)	-0.001	0.030	0.046	0.122*	0.025	-0.170*	0.005	-0.119
	[0.045]	[0.044]	[0.043]	[0.068]	[0.054]	[0.088]	[0.021]	[0.081]
Log (k/l)	0.052*	0.050*						
	[0.028]	[0.027]						
Log (equipment k / l)			0.101***	0.033	0.175***	0.161**	0.028*	0.116**
			[0.036]	[0.049]	[0.045]	[0.066]	[0.017]	[0.052]
Log (plant k / l)			-0.079*	-0.005	-0.168**	-0.095	-0.054***	-0.104**
			[0.048]	[0.061]	[0.068]	[0.071]	[0.020]	[0.048]
Log (materials/l)	0.054	0.046	0.051	0.020	0.063	0.037	0.019	0.067
	[0.034]	[0.034]	[0.033]	[0.051]	[0.046]	[0.059]	[0.014]	[0.049]
Log (0.001+ R&D/Sales)	0.056***	0.052***	0.051***	0.049***	0.049***	0.088***	0.032***	0.071***
	[0.009]	[0.009]	[0.009]	[0.014]	[0.014]	[0.019]	[0.004]	[0.016]
Dispersion	0.088	0.086	0.137*	0.051	0.249**	0.234	0.108***	0.135
	[0.072]	[0.074]	[0.079]	[0.110]	[0.105]	[0.149]	[0.041]	[0.121]
DFShare	0.034			-0.149*	0.236***			
	[0.051]			[0.076]	[0.065]			
DFShare X 1(Elas < Median)		-0.109	-0.079			-0.145	-0.057	-0.068
		[0.068]	[0.069]			[0.103]	[0.037]	[0.092]
DFShare X 1(Elas > Median)		0.165***	0.194***			0.407***	-0.044	0.290***
		[0.062]	[0.063]			[0.118]	[0.027]	[0.106]
1(Elas > Median)		-0.165**	-0.160**			-0.422***	-0.008	-0.296***
		[0.069]	[0.068]			[0.096]	[0.034]	[0.084]
Industry controls for:	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer
Year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Country-Year fixed effects?	No	No	No	No	No	No	Yes	Yes
Observations	2783	2783	2783	1375	1408	2783	207991	207991
R-squared	0.27	0.31	0.32	0.35	0.30	0.59	0.18	0.58

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. Standard errors are clustered by industry. Columns 1-6 use industry-year observations controlling for year fixed effects, while Columns 7-8 use country-industry-year observations controlling for country-year fixed effects. Estimation is by OLS. In all columns, the industry factor intensity and dispersion variables are a weighted average of the characteristics of buyer industries (the industries that buy the input in question). Columns 4 and 5 restrict the sample to observations where the buyer industry elasticity is smaller (respectively larger) than the industry median value. "Weighted" columns use the value of total imports for the industry-year or country-industry-year respectively as regression weights.

Appendix Table 4
Downstreamness and the Intrafirm Import Share: Final Use Share

	Dependent variable:	Intrafirm Import Share						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Elas < Median	Elas >= Median	Weighted		Weighted
Log (s/l)	-0.018	0.005	0.022	0.071	0.017	-0.206***	-0.003	-0.142**
	[0.045]	[0.043]	[0.042]	[0.067]	[0.053]	[0.071]	[0.020]	[0.060]
Log (k/l)	0.063**	0.059**						
	[0.027]	[0.026]						
Log (equipment k / l)			0.123***	0.079*	0.171***	0.136**	0.047***	0.117***
			[0.034]	[0.044]	[0.048]	[0.066]	[0.015]	[0.045]
Log (plant k / l)			-0.099**	-0.041	-0.175**	-0.077	-0.068***	-0.100**
			[0.048]	[0.060]	[0.076]	[0.080]	[0.020]	[0.049]
Log (materials/l)	0.050	0.041	0.048	0.021	0.064	0.034	0.017	0.052
	[0.033]	[0.033]	[0.033]	[0.050]	[0.045]	[0.059]	[0.013]	[0.045]
Log (0.001+ R&D/Sales)	0.058***	0.055***	0.055***	0.056***	0.048***	0.095***	0.034***	0.075***
	[0.009]	[0.009]	[0.009]	[0.014]	[0.014]	[0.018]	[0.004]	[0.014]
Dispersion	0.092	0.093	0.152*	0.087	0.252**	0.272*	0.118***	0.179
	[0.073]	[0.076]	[0.080]	[0.114]	[0.111]	[0.161]	[0.044]	[0.121]
FShare	0.069**			0.017	0.167***			
	[0.032]			[0.040]	[0.048]			
FShare X 1(Elas < Median)		0.02	0.045			-0.063	0.021	0.003
		[0.040]	[0.040]			[0.071]	[0.021]	[0.059]
FShare X 1(Elas > Median)		0.124***	0.149***			0.288***	-0.019	0.243***
		[0.048]	[0.046]			[0.071]	[0.019]	[0.059]
1(Elas > Median)		-0.006	-0.002			-0.168***	0.019	-0.133***
		[0.034]	[0.034]			[0.052]	[0.018]	[0.047]
Industry controls for:	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer
Year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Country-Year fixed effects?	No	No	No	No	No	No	Yes	Yes
Observations	2783	2783	2783	1375	1408	2783	207991	207991
R-squared	0.29	0.30	0.32	0.33	0.30	0.61	0.18	0.60

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. Standard errors are clustered by industry. Columns 1-6 use industry-year observations controlling for year fixed effects, while Columns 7-8 use country-industry-year observations controlling for country-year fixed effects. Estimation is by OLS. In all columns, the industry factor intensity and dispersion variables are a weighted average of the characteristics of buyer industries (the industries that buy the input in question). Columns 4 and 5 restrict the sample to observations where the buyer industry elasticity is smaller (respectively larger) than the industry median value. "Weighted" columns use the value of total imports for the industry-year or country-industry-year respectively as regression weights.

Appendix Table 5
Robustness Checks with the Country-Industry-Year Specifications: DUse_TUse

	Dependent variable: Intrafirm Import Share					
	(1)	(2)	(3)	(4)	(5)	(6)
	Weighted	Weighted	Weighted	Weighted	Weighted	Weighted
DUse_TUse X 1(Elas < Median)	-0.067	-0.098	-0.047	-0.107	-0.109	-0.104
	[0.074]	[0.078]	[0.072]	[0.073]	[0.075]	[0.074]
DUse_TUse X 1(Elas > Median)	0.368***	0.375***	0.340***	0.292***	0.304***	0.325***
	[0.134]	[0.102]	[0.118]	[0.095]	[0.092]	[0.073]
Value-added / Value shipments	-0.092					-0.026
	[0.264]					[0.163]
Input "Importance"		-4.275***				-4.610***
		[0.995]				[0.744]
Intermediation			-0.425***			-0.386***
			[0.137]			[0.115]
Own contractibility				0.193***	-0.002	-0.002
				[0.067]	[0.133]	[0.125]
Own contractibility					0.276*	0.306*
X Country Rule of Law					[0.165]	[0.162]
Buyer contractibility				-0.514***	-0.612***	-0.594***
				[0.100]	[0.167]	[0.168]
Buyer contractibility					0.150	0.082
X Country Rule of Law					[0.200]	[0.199]
	Additional buyer industry controls included: 1(Elas > Median), Log (s/l), Log (equipment k / l), Log (plant k / l), Log (materials/l), Log (0.001+ R&D/Sales), Dispersion					
Country-year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	207991	207991	207991	207991	174274	174274
R-squared	0.59	0.61	0.60	0.62	0.62	0.65

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. Standard errors are clustered by industry. All columns use country-industry-year observations controlling for country-year fixed effects. Estimation is by OLS. The value-added / value shipments, intermediation, input "importance", and own contractibility variables refer to characteristics of the seller industry (namely, the industry that sells the input in question), while the buyer contractibility variable is a weighted average of the contractibility of buyer industries (the industries that buy the input in question). The contractibility variables are further interacted with a country rule of law index in Columns 5-6. All columns include additional control variables whose coefficients are not reported, namely: (i) the level effect of the buyer industry elasticity dummy, and (ii) buyer industry factor intensity and dispersion variables. "Weighted" columns use the value of total imports for the country-industry-year as regression weights.

Appendix Table 6
Robustness Checks with the Country-Industry-Year Specifications: DownMeasure

	Dependent variable: Intrafirm Import Share					
	(1)	(2)	(3)	(4)	(5)	(6)
	Weighted	Weighted	Weighted	Weighted	Weighted	Weighted
DownMeasure X 1(Elas < Median)	-0.010	-0.052	0.042	-0.083	-0.098	-0.144
	[0.093]	[0.091]	[0.091]	[0.090]	[0.090]	[0.090]
DownMeasure X 1(Elas > Median)	0.439***	0.397***	0.429***	0.394***	0.398***	0.317***
	[0.089]	[0.085]	[0.088]	[0.074]	[0.075]	[0.054]
Value-added / Value shipments	0.130					0.173
	[0.207]					[0.131]
Input "Importance"		-2.660***				-3.511***
		[0.600]				[0.544]
Intermediation			-0.411***			-0.353***
			[0.124]			[0.113]
Own contractibility				0.220***	-0.001	-0.018
				[0.065]	[0.130]	[0.116]
Own contractibility					0.313*	0.337**
X Country Rule of Law					[0.163]	[0.158]
Buyer contractibility				-0.506***	-0.586***	-0.578***
				[0.095]	[0.169]	[0.166]
Buyer contractibility					0.120	0.064
X Country Rule of Law					[0.200]	[0.202]
	Additional buyer industry controls included: 1(Elas > Median), Log (s/l), Log (equipment k / l), Log (plant k / l), Log (materials/l), Log (0.001+ R&D/Sales), Dispersion					
Country-year fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	207991	207991	207991	207991	174274	174274
R-squared	0.61	0.62	0.62	0.64	0.64	0.66

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels respectively. Standard errors are clustered by industry. All columns use country-industry-year observations controlling for country-year fixed effects. Estimation is by OLS. The value-added / value shipments, intermediation, input "importance", and own contractibility variables refer to characteristics of the seller industry (namely, the industry that sells the input in question), while the buyer contractibility variable is a weighted average of the contractibility of buyer industries (the industries that buy the input in question). The contractibility variables are further interacted with a country rule of law index in Columns 5-6. All columns include additional control variables whose coefficients are not reported, namely: (i) the level effect of the buyer industry elasticity dummy, and (ii) buyer industry factor intensity and dispersion variables. "Weighted" columns use the value of total imports for the country-industry-year as regression weights.