Global Value Chain Under Imperfect Capital Markets

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Abstract

This paper develops a model to study how suppliers' financial constraints interact with suppliers' positioning in a global value chain. We embed financial frictions into the property-rights model of the global value chain in Antràs and Chor (2013). The model predicts that downstream intermediate inputs are more likely to be sourced from financially developed countries and final-good producers are more likely to integrate downstream intermediate input suppliers in countries with weak financial institutions when sequential complements characterize the production process.

Keywords: Global value chain; Imperfect capital markets.

JEL Code: D23, F12, F23, L23, 016

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1 Introduction

The production process has become closely intertwined across countries. It is no wonder that intermediate products cross borders several times to make a final product. The phenomenon of "Global value chain" has been broadly studied by researchers in the field of international trade. Starting from Dixit and Grossman (1982), several studies have investigated the economic impact of global value chain on patterns of specialization or organizational form (Feenstra and Hanson, 1996; Grossman and Rossi-Hansberg, 2008; Costinot, Vogel and Wang, 2013; Antràs and Chor, 2013). However, little work has been done yet on how financial constraints affect patterns of specialization and organizational form along the global value chain.

In this paper, we develop a model to study how financial constraints interact with suppliers' positioning in a global value chain. Specifically, we extend the property-rights model of the global value chain in Antràs and Chor (2013) to allow for financial frictions as in Carluccio and Fally (2012). Based on Antràs and Chor (2013), we further consider that financial markets are imperfect such that suppliers may be financially constrained to contract with a final-good producer.

The core finding is that financial frictions affect optimal organizational structure along the global value chain. When the production process is sequential complements, and financial constraints are not binding, the final-good producer finds it optimal to choose to outsource for all stages. Suppliers are more likely to invest in outsourcing than vertical integration because the supplier receives a more significant share of the ex-post joint surplus. On the other hand, vertical integration requires fewer upfront transfers so that it alleviates the problem of financial constraints. Facing the trade-off between the under-investment and the financial constraints, it is always optimal for final-good producer to choose to outsource when financial constraints are not binding.

However, if financial constraints are binding, then the final-good producer vertically integrate suppliers for some stages to alleviate the problem of financial constraints because vertical integration requires less upfront transfers. Furthermore, we find that upfront transfers are higher for the most downstream stages under sequential complements. Hence, liquidity constraints are more likely to be binding for downstream stages, and vertical integration arises from the most downstream stages when the production process is sequential complements.

Our findings will have clear applications in multinational firms' sourcing strategy. As multinationals require more upfront transfers in downstream stages, downstream intermediate inputs are more likely to be sourced from finanically developed countries. Next, vertical integration arises as a result of alleviating financial constraints problem. Hence, multinationals are more likely to vertically integrate downstream intermediate suppliers in countries with weak financial development.

Our model is closely related to multinational firms sourcing strategy under credit constraints. Carluccio and Fally (2012) study multinational firms' under a supplier's credit constraints and contractual frictions. In the model, there are two tasks: basic task and complex task. Complex tasks are relation-specific, and thus it is hard to sign a contract between a multinational firm and a supplier. The standard hold-up problem arises, and the multinational firm requires a higher compensating transfer fee from a supplier. Suppliers need more initial capital in case of complex tasks. Through this mechanism, they study the linkage between credit constraints and contractual frictions.

Similar to Carluccio and Fally (2012), Basco (2013) studies a final-good producer's offshoring decision under financial development differences across countries. A final-good producer in the North can source intermediate inputs from either Northern suppliers or Sothern suppliers. They assume Northern suppliers require higher wages while Northern countries have a good financial system. Suppliers have to pay initial fixed costs which can be financed from the final producer and domestic banks. In financially under-developed South, the suppliers cannot pledge enough amount of future profits. Thus, they need to receive a transfer from a final-good producer. Then, the final producer raises her ex-post share to compensate for giving more transfer to the supplier, which leads to distortion of the contract. The final producer confronts trade-off between cost efficiency and contractual friction.

Compared to prior work (Carluccio and Fally, 2012; Basco, 2013), we focus on how credit constraints affect firm's organizational choices along the global value chain, which allows us to investigate the differential impacts of credit constraints on different stages of production chains, i.e., upstream versus downstream.

Concerning the modeling framework, we build upon the property-rights model of the global value chain in Antràs and Chor (2013). They study how an organizational form is determined by the sequential production stages using the property-rights model of the firm. The hold-up problem arises as a result of an incomplete contract. They study how incomplete contract interacts along the global value chain, and show that the optimal organizational mode depends crucially on two parameters: the degree of substitution between final goods and the degree of substitution between input stages. In this paper, we go beyond the work of Antràs and Chor (2013) by allowing credit constraints along the global value chain. We show that credit constraints play a crucial role in shaping organizational forms and profit structure.

Another related study is Kim and Shin (2012). They investigate a role of financial linkages between firms for sustaining production chains. Like our model, a sequential stage is needed to make a final product. However, there is a time dimension that each stage takes one unit of time. When a firm has an option to choose between high effort and low effort, then the production chain may not be sustainable due to the hold-up problem. To solve the hold-up problem in the production chain, the authors develop an idea of delays in payment between firms: accounts receivable and accounts payable. Because firms tightly link each other via trade credit, the production chain can be sustainable. However, if firms are credit constrained, it is not possible to participate in production chains. Moreover, due to long delays in payments, upstream firms need more working capital than downstream firms, and longer production chains require more demands on working capital needs. However, we provide a different mechanism that this is not necessarily the case. Downstream stages require more initial liquidity holdings when the production process is sequential complements in our model.

Turning to empirical evidence, Antràs and Chor (2013) and Alfaro, Antràs, Chor and Conconi (2018) provide supporting evidence of the property-rights model of firm boundary choices along the global value chain using industry-level and firm-level, respectively. They find that whether a firm integrates upstream or downstream suppliers depends crucially on the elasticity of demand for the final product. However, the modeling framework is based upon complete financial markets in their model, and thus our predictions have new components such that the determinants of organizational choices along the global value chain interact with financial constraints.

2 Model

2.1 Production

As in Antràs and Chor (2013), there are one final-good producer and a large number of suppliers. Production process requires a continuum of stages indexed by $j \in [0, 1]$ where a higher j denotes downstream stages, and a lower j corresponds to upstream stages. In each stage, a supplier produces relationship-specific intermediate input that is requested by the final-good producer. The production function is as follows:

$$q = \left(\int_0^1 x(j)^\alpha I(j) dj \right)^{1/\alpha}$$

where $\alpha \in (0, 1)$ indicates the degree of substitution between stage inputs, $x(j)$ is the intermediate input that supplier j delivers to the final-good producer, and $I(j)$ denotes the indicator function such that it equals 1 if input j is produced after all inputs $j' < j$ have been produced and it equals 0 if otherwise. The production function can be expressed in the differential form:

$$q'(m) = \frac{1}{\alpha} x(m)^\alpha q(m)^{1-\alpha} I(m)$$

where $q(m) = \left(\int_0^m x(j)^\alpha I(j) dj \right)^{1/\alpha}$. The marginal increase in production is the Cobb-Douglas function of a stage m supplier's input production and the production generated up to that stage.

There are a large number of profit-maximizing suppliers whose outside option is 0, and they can participate in input production. The marginal cost of investment is c for all stages $j \in [0, 1]$. One unit of investment generates one unit of stage-j compatible intermediate input. The input production is relationship-specific to the final-good producer, and hence the stage-j input is obsolete to other buyers. Therefore, an enforceable contract between suppliers and the final-good producer is impossible (Grossman and Hart, 1986).

2.2 Demand

Consumers have preferences with a constant elasticity of substitution across varieties:

$$U = \left(\int_{\omega \in \Omega} q(\omega)^{\rho} d\omega \right)^{1/\rho}$$

where Ω is the set of varieties and $\rho \in (0, 1)$ is the degree of substitution between varieties. Combining the production technology and the preference of consumers, the revenue of the final-good producer is represented as:

$$r = A^{1-\rho} \left(\int_0^1 x(j)^{\alpha} I(j) dj \right)^{\rho/\alpha}$$

where $A > 0$ is the industry-wide demand shifter.

2.3 Incomplete Contracts

The production of relation-specific intermediate input by suppliers generates a hold-up problem. If contracts were signed ex-ante between two parties, suppliers have every incentive to produce incompatible inputs with lower costs. A court of law cannot verify the value of the inputs that suppliers produced. Thus, payments to suppliers occur only after suppliers have produced the intermediate inputs and the final-good producer has investigated the quality of them. Because the intermediate input-m is only compatible with the final-good producer's output, the outside option for supplier-m is zero. Hence, total surplus that needs to be divided between the supplier m and the final-good producer is given by the incremental contribution to total revenue generated by supplier-m at that stage. To compute the incremental contribution by the supplier m, we have $I(j) = 1$ for all $j < m$, and the value of final-good production secured up to that stage is given by:

$$r(m) = A^{1-\rho} \left(\int_0^m x(j)^\alpha dj \right)^{\rho/\alpha}.$$

Then, the additional contribution of stage-m supplier is given by:

$$r'(m) = \frac{\partial r(m)}{\partial m} = \frac{\rho}{\alpha} (A^{1-\rho})^{\alpha/\rho} r(m)^{(\rho-\alpha)/\rho} x(m)^\alpha. \tag{1}$$

In line with Grossman and Hart (1986), the organizational structure determines the share of quasi-rents that is distributed between the supplier and the final-good producer. For simplicity, the final-good producer will obtain $\beta_v r'(m)$ when the organizational structure is vertical integration mode while the final-good producer will secure the $\beta_o r'(m)$ when the organizational structure is outsourcing mode. We assume that $\beta_v > \beta_o$.

2.4 Financial Constraints

Following Carluccio and Fally (2012), we assume that financial markets are imperfect in that suppliers may be constrained to contract with a final-good producer at the beginning due to liquidity constraints while final-good producers are assumed to be financially sound. A supplier-m needs initial costs $cx(m)$ and upfront transfer $T(m)$ that is requested by the final-good producer to start operating. Positive upfront transfer $T(m)$ means licensing fee or royalty for participating in the production while we can interpret negative transfer $T(m)$ as FDI or co-financing. The supplier's initial liquidity is composed of two parts: Initial cash holdings $W(m)$ and debt $L(m)$ from local banks. The liquidity constraint is as follows:

$$T(m) + cx(m) \leq W(m) + L(m).$$

The supplier can borrow $\kappa \in [0, 1]$ of its future revenue Y_s from the local banks. The parameter κ indicates the level of financial development. Thus, debt L is limited as:

$$L(m) \leq \kappa Y_s.$$

2.5 Timeline

The timeline of the game between the final-good producer and a continuum of suppliers is given by:

1. The final-good producer posts contracts for each stage $m \in [0, 1]$ to a continuum of suppliers specifying the amount of upfront transfer $T(m)$ and the organizational form $\beta(m)$: vertical integration or arm's length outsourcing. The upfront transfer may limit some liquidity constrained suppliers to enter the market.

2. Suppliers apply for each stage, and the final-good producer selects only one supplier for each stage. Selected suppliers pay initial transfer $T(m)$ to the final-good producer.

3. Production takes place sequentially; Each supplier receives the final good completed up to that stage $r(m)$. Then, the supplier decides its level of investment $x(m)$ under the constraint that its initial upfront transfer and investment cost cannot exceed the initial liquidity holdings.

4. The final-good producer and supplier m bargain over the quasi-rent $r'(m)$, and the final-good producer pays the supplier. The supplier j repays external debt from local banks.

5. When the final stage is completed, the final-good producer sells it in the market and receives total revenue $A^{1-\rho}q^{\rho}$.

2.6 Sequential Complements and Sequential Substitutes

Following Antràs and Chor (2013), we define sequential complements if $\rho > \alpha$ and sequential complements if $\rho < \alpha$. We focus our analysis on the case where the following restriction hold:

Assumption 1 *Production process is sequential complements, i.e., $\rho > \alpha$.*

3 Solution

3.1 The maximization problem of the final-good producer

The final-good producer's total profit equals to its ex-post revenues plus transfers from suppliers. The final-good producer chooses organizational form $\beta(m) \in \{\beta_v, \beta_o\}$ and upfront transfer amount $T(m)$ for all stages $m \in [0, 1]$ given three constraints: the participation constraint [PC], the financial constraint [FC], and the incentive compatibility constraint [IC].

$$\max_{\{\beta(m),T(m)\}_{m\in[0,1]}} \pi_F = \int_0^1 \beta(m)r'(m)dm + \int_0^1 T(m)dm$$

$$\begin{aligned}
\text{subject to} \quad & T(m) \leq (1-\beta(m))r'(m) - cx(m) \quad \forall m \quad [PC] \\
& T(m) \leq W(m) + \kappa[(1-\beta(m))r'(m)] - cx(m) \quad \forall m \quad [FC] \\
& x(m) = \arg\max_{x(m)} \{(1-\beta(m))r'(m) - cx(m)\} \quad \forall m \quad [IC]
\end{aligned}$$

3.2 Suppliers' optimal investments

Consider the problem of stage-m supplier which is described by the incentive compatibility constraint. The supplier maximizes its ex-post revenues net of its costs given the final product up to that stage and the organizational form chosen by the final-good producer:

$$\begin{aligned}
\max_{x(m)} \pi_S &= (1-\beta(m))r'(m) - cx(m) \\
&= (1-\beta(m))\frac{\rho}{\alpha}(A^{1-\rho})^{\alpha/\rho} r(m)^{(\rho-\alpha)/\rho} x(m)^{\alpha} - cx(m).
\end{aligned}$$

The optimal investment for stage-m supplier is given by:

$$x(m) = \left((1-\beta(m))\frac{\rho(A^{1-\rho})^{\alpha/\rho}}{c}\right)^{1/(1-\alpha)} r(m)^{(\rho-\alpha)/(\rho(1-\alpha))}. \tag{2}$$

The investment level for the stage-m supplier is increasing in demand A and the bargaining share for supplier $1-\beta(m)$. The investment level is bigger in outsourcing case β_o than the one in vertical integration case β_v. Under-investment problem is bigger in vertical integration case because the supplier receives a smaller share of ex-post quasi-rents. The investment is decreasing in marginal cost c. And it increases in the value of final-good production secured up to that stage $r(m)$ under Assumption 1, which implies that the higher investment by previous suppliers increases the marginal return of supplier-m's investment.

Plugging the optimal investment for stage-m, $x(m)$, in equation (2) into equation (1),

$$r'(m) = \frac{\rho}{\alpha}\left((1-\beta(m))\frac{\rho}{c}\right)^{\alpha/(1-\alpha)}(A^{1-\rho})^{\alpha/\rho(1-\alpha)}r(m)^{(\rho-\alpha)/(\rho(1-\alpha))}. \quad (3)$$

Solving the above differential equation with the initial condition $r(0) = 0$ yields,

$$\begin{aligned} r(m) = {} & A\left(\frac{1-\rho}{1-\alpha}\right)^{\rho(1-\alpha)/(\alpha(1-\rho))}\left(\frac{\rho}{c}\right)^{\rho/(1-\rho)} \\ & \times\left[\int_0^m (1-\beta(j))^{\alpha/(1-\alpha)}dj\right]^{\rho(1-\alpha)/(\alpha(1-\rho))}. \end{aligned} \quad (4)$$

Plugging this revenue function into equation (2) yields,

$$\begin{aligned} x(m) = {} & \left((1-\beta(m))\frac{\rho(A^{1-\rho})^{\alpha/\rho}}{c}\right)^{1/(1-\alpha)} \\ & \times\left[A\left(\frac{1-\rho}{1-\alpha}\right)^{\rho(1-\alpha)/(\alpha(1-\rho))}\left(\frac{\rho}{c}\right)^{\rho/(1-\rho)}\right]^{(\rho-\alpha)/(\rho(1-\alpha))} \\ & \times\left[\int_0^m (1-\beta(j))^{\alpha/(1-\alpha)}dj\right]^{(\rho-\alpha)/(\alpha(1-\rho))}. \end{aligned} \quad (5)$$

As can be easily seen from this expression, the investment level for the stage-m supplier depends on the previous organizational choices of the final-good producer.

Proposition 1 *Under Assumption 1 and the bargaining shares are constants along the global value chain $\beta(m) = \beta$, the investment level $x(m)$ is an increasing function for m.*

Proof. Differentiating the investment level $x(m)$ in equation (5) with respect to m yields the result, i.e., $\dfrac{\partial x(m)}{\partial m} > 0$. ∎

3.3 Upfront transfers and optimal organization structure

3.3.1 Financial constraint is not binding

Consider the case where all suppliers' initial liquidity holdings are sufficient to cover upfront transfers and costs. Then, the participation constraint determines the upfront transfer $T(m)$ from supplier m to the final-good producer. Plugging the optimal investment level $x(m)$ in equation (2) into the participation constraint yields the optimal upfront transfer $\overline{T}(m)$ as follows:

$$\begin{aligned}\overline{T}(m) = {} & (1-\beta(m))^{1/(1-\alpha)} r(m)^{\rho-\alpha/\rho(1-\alpha)} \\ & \times \rho^{1/(1-\alpha)} (A^{1-\rho})^{\alpha/\rho(1-\alpha)} (\frac{1}{c})^{\alpha/(1-\alpha)} (\frac{1-\alpha}{\alpha}).\end{aligned} \tag{6}$$

Let $\overline{T}(m)_v$ be the optimal transfer under vertical integration and $\overline{T}(m)_o$ be the optimal transfer under outsourcing. Given the value of final good production up to the stage m, the vertical intergrated supplier pays less initial upfront transfer $\overline{T}(m)_v$ than the stand-alone supplier $\overline{T}(m)_o$.

Then, given the organizational form $\beta(m)$, how does the upfront transfer change with suppliers' positioning in the global value chain? Plugging the revenue function in equation (4) into the optimal upfront transfer equation (6) yields,

$$
\begin{aligned}
\overline{T}(m) &= (1-\beta(m))^{1/(1-\alpha)}\rho^{1/(1-\alpha)}(A^{1-\rho})^{\alpha/\rho(1-\alpha)}(\frac{1}{c})^{\alpha/(1-\alpha)}(\frac{1-\alpha}{\alpha}) \\
&\times \left[A\left(\frac{1-\rho}{1-\alpha}\right)^{\rho(1-\alpha)/(\alpha(1-\rho))}\left(\frac{\rho}{c}\right)^{\rho/(1-\rho)}\right]^{\rho-\alpha/\rho(1-\alpha)} \\
&\times \left[\int_0^m (1-\beta(j))^{\alpha/(1-\alpha)}dj\right]^{\rho-\alpha/(\alpha(1-\rho))}. \qquad (7)
\end{aligned}
$$

Proposition 2 *Under Assumption 1 and the organizational form $\beta(m)$ is given, the upfront transfer $\overline{T}(m)$ is an increasing function for m.*

Proof. Differentiating the upfront transfer $\overline{T}(m)$ in equation (7) with respect to m yields the result, i.e., $\frac{\partial\overline{T}(m)}{\partial m} > 0$. ■

When the financial constraint is not binding, the final-good producer can extract all the quasi-rents. Thus, the profit of final-good producer is the joint surplus created along the global value chain. Plugging the participation contraint equation into the final-good producer's profit equation and using the equation $cx(m) = \alpha(1-\beta(m))r'(m)$ that is derived from the zero-profit condition for suppliers, we can derive the following profit equation:

$$
\begin{aligned}
\overline{\pi}_F &= \int_0^1 \beta(m)r'(m)dm + \int_0^1 \left[(1-\beta(m))r'(m) - cx(m)\right]dm \\
&= \int_0^1 \left[1-\alpha(1-\beta(m))\right]r'(m)dm \qquad (8)
\end{aligned}
$$

Substituting the expressions from equations (3) and (4) into the equation (8) yields,

$$\overline{\pi}_F = \Theta \int_0^1 \left[1 - \alpha(1 - \beta(m))\right] (1 - \beta(m))^{\alpha/(1-\alpha)} \times \left[\int_0^m (1 - \beta(j))^{\alpha/(1-\alpha)} dj\right]^{(\rho-\alpha)/(\alpha(1-\rho))} dm$$

where $\Theta \equiv A\frac{\rho}{\alpha}\left(\frac{1-\rho}{1-\alpha}\right)^{(\rho-\alpha)/(\alpha(1-\rho))}\left(\frac{\rho}{c}\right)^{\rho/(1-\rho)}$ is a positive constant.

Let us solve the optimal organizational structure $\overline{\beta}(m)$. Defining

$$v(m) \equiv \int_0^m (1 - \beta(j))^{\frac{\alpha}{1-\alpha}} dj,$$

we can write $\overline{\pi}_F$ as

$$\overline{\pi}_F(v) = \Theta \int_0^1 \left(1 - \alpha v'(m)^{(1-\alpha)/\alpha}\right) v'(m) \left[v(m)\right]^{(\rho-\alpha)/(\alpha(1-\rho))} dm.$$

Finding maxima of functional $\overline{\pi}_F(v)$ is the calculus of variation problem, and we need to derive the Euler - Lagrange equation associated with choosing the real-valued function $v(m)$ that maximizes the functional $\overline{\pi}_F(v)$. Once we obtain $v(m)$, the optimal orgainzation structure $\overline{\beta}(m)$ can be derived using $\overline{\beta}(m) = 1 - v'(m)^{(1-\alpha)/\alpha}$.

Proposition 3 *When financial constraint is not binding, the optimal orginization structure $\overline{\beta}(m)$ is given by:*

$$\overline{\beta}(m) = 1 - m^{(\alpha-\rho)/\alpha}.$$

Proof. Let $\mathcal{L} \equiv \left(1 - \alpha(v')^{(1-\alpha)/\alpha}\right) v' v^{(\rho-\alpha)/(\alpha(1-\rho))}$.

$$\frac{\partial \mathcal{L}}{\partial v} = \frac{\rho - \alpha}{\alpha(1-\rho)} \left(1 - \alpha(v')^{(1-\alpha)/\alpha}\right) v' v^{(\rho-\alpha)/(\alpha(1-\rho))-1},$$
$$\frac{\partial \mathcal{L}}{\partial v'} = \left(1 - (v')^{(1-\alpha)/\alpha}\right) v^{(\rho-\alpha)/(\alpha(1-\rho))}.$$

The Euler-Lagrange equation, then, is given by

$$
\begin{aligned}
&\frac{\partial \mathcal{L}}{\partial v} - \frac{d}{dm}\frac{\partial \mathcal{L}}{\partial v'} = 0 \\
\iff & v^{(\rho-\alpha)/(\alpha(1-\rho))}(v')^{(1-\alpha)/\alpha-1}\frac{1-\alpha}{\alpha}\left[v'' + \frac{\rho-\alpha}{(1-\rho)}\frac{(v')^2}{v}\right] = 0.
\end{aligned}
$$

There are three types of solutions associated with the above equation, and we focus on the case which generates a strictly positive profit for the final-good producer:

$$
v'' + \frac{\rho-\alpha}{(1-\rho)}\frac{(v')^2}{v} = 0.
$$

Solving the second-order differential equation yields,

$$
\begin{aligned}
v(m) &= \left(\frac{(1-\alpha)C_1}{1-\rho}(m-C_2)\right)^{(1-\rho)/(1-\alpha)}, \\
v'(m) &= C_1\left(\frac{(1-\alpha)C_1}{1-\rho}(m-C_2)\right)^{(\alpha-\rho)/(1-\alpha)}.
\end{aligned}
$$

where C_1 is a positive constant and C_2 is a second constant of integration. The initial condition is given by $v(0) = 0$ and the transversality condition is $v'(1)^{(1-\alpha)/\alpha} = 1$ at the right boundary of the unit interval. Using the two conditions, we can obtain $C_1 = \left[\frac{1-\rho}{1-\alpha}\right]^{(\alpha-\rho)/(1-\rho)}$ and $C_2 = 0$. Plugging C_1 and C_2 into the $v'(m)$ equation, we obtain

$$
v'(m) = m^{(\alpha-\rho)/(1-\alpha)}.
$$

Therefore,

$$
\overline{\beta}(m) = 1 - v'(m)^{(1-\alpha)/\alpha} = 1 - m^{(\alpha-\rho)/\alpha}.
$$

■

Proposition 4 *Suppose that Assumption 1 holds and the financial constraint is not bind-*

ing. Then,

(i) $\overline{\beta}(m)$ is increasing for all $m \in [0,1]$;

(ii) The final-good producer finds it optimal to choose outsourcing for all stages.

Proof. (i) If $\rho > \alpha$, then $\dfrac{\partial \overline{\beta}(m)}{\partial m} > 0$ for all $m \in [0,1]$.

(ii) Because $\overline{\beta}(1) = 0$ and $\overline{\beta}(m)$ is an increasing function, it must be that $\overline{\beta}(m) \leq 0$ for all $m \in [0,1]$. The final-good producer would select the minimum possible value of $\overline{\beta}(m)$ for all stages. Because $\beta_v > \beta_o$, the outsourcing is optimal for all stages. ∎

Because the final-good producer can extract quasi-rents using upfront transfers, the use of the vertical integration is not efficient. The vertical integration will only be to exacerbate the reduction in investment level for suppliers. Therefore, outsourcing is optimal for all stages.

3.3.2 Financial constraint is binding

Consider a case where the financial constraint is now binding. In this case, the optimal transfer $T(m)$ does not satisfy the inequality in the financial constraint equation. This case occurs when initial cash holding $W(m)$ is below a threshold in which the threshold cash holdings $\widetilde{W}(m)$ is given by:

$$\begin{aligned}\widetilde{W}(m) = {} & (1-\beta(m))^{1/(1-\alpha)} r(m)^{\rho-\alpha/\rho(1-\alpha)} \\ & \times \rho^{1/(1-\alpha)} (A^{1-\rho})^{\alpha/\rho(1-\alpha)} (\frac{1}{c})^{\alpha/(1-\alpha)} (\frac{1-\kappa}{\alpha}).\end{aligned} \tag{9}$$

Plugging the revenue function in equation (4) into the threshold equation (9) yields,

$$\begin{aligned}\widetilde{W}(m) &= (1-\beta(m))^{1/(1-\alpha)}\rho^{1/(1-\alpha)}(A^{1-\rho})^{\alpha/\rho(1-\alpha)}(\frac{1}{c})^{\alpha/(1-\alpha)}(\frac{1-\kappa}{\alpha}) \\ &\times \left[A\left(\frac{1-\rho}{1-\alpha}\right)^{\rho(1-\alpha)/(\alpha(1-\rho))}\left(\frac{\rho}{c}\right)^{\rho/(1-\rho)}\right]^{\rho-\alpha/\rho(1-\alpha)} \\ &\times \left[\int_0^m (1-\beta(j))^{\alpha/(1-\alpha)}dj\right]^{\rho-\alpha/(\alpha(1-\rho))}. \end{aligned} \tag{10}$$

Let $\widetilde{W}(m)_v$ be the threshold cash holdings under vertical integration and $\widetilde{W}(m)_o$ be the threshold cash holdings under outsourcing. Financial constraints are less likely to be binding for the vertically integrated supplier than the stand-alone supplier $\widetilde{W}(m)_o > \widetilde{W}(m)_v$. It is because the final-good producer can retain a more share of quasi-rents and thus asks for fewer upfront transfers to suppliers in the vertically integrated case.

Proposition 5 *Under Assumption 1 and the organizational form $\beta(m)$ is given,*

(i) The threshold cash holdings $\widetilde{W}(m)$ is an increasing function for m;

(ii) Financial development κ decreases the threshold cash holdings $\widetilde{W}(m)$;

(iii) The effect of financial development κ on the threshold cash holding $\widetilde{W}(m)$ is stronger especially in downstream stages.

Proof. (i) Differentiating the threshold cash holdings $\widetilde{W}(m)$ in equation (10) with respect to m yields the result, i.e., $\frac{\partial \widetilde{W}(m)}{\partial m} > 0$.

(ii) Differentiating the threshold cash holdings $\widetilde{W}(m)$ in equation (10) with respect to κ yields the result, i.e., $\frac{\partial \widetilde{W}(m)}{\partial \kappa} < 0$.

(iii) Take the partial derivative of $\widetilde{W}(m)$ in equation (10) with respect to m. Then, taking the partial derivative again with respect to κ yields the result, i.e., $\frac{\partial^2 \widetilde{W}(m)}{\partial \kappa \partial m} < 0$. ■

It is worth noting that the possibility of financial constraints being binding increases as we move toward the downstream stages. Intuitively, when production process is sequential complements, the additional contribution of stage-m supplier, $r'(m)$, increases in m. Since ex-ante transfers allow the final-good producer to extract the joint surplus from its suppliers, the final-good producer requires more upfront transfers from higher m suppliers, which implies that the downstream suppliers require more initial liquidity holdings at the beginning. This prediction is different from Kim and Shin (2012)'s result that upstream firms need more working capital than downstream firms which stems from upstream firms to face long delays in payments.

Financial development alleviates the liquidity constraints problem for all stages along the global value chain. The benefits are biased toward downstream stages than upstream stages as downstream stages are more vulnerable to the financial constraints. Also, note that downstream suppliers who have less initial cash holdings than the threshold $W(m) < \widetilde{W}(m)$ earn positive profits. It may seem counterintuitive, but financial underdevelopment acts as increases in bargaining power for financially constraint suppliers, as the liquidity constraint limits upfront transfers to the final-good producer. Because downstream stages are more likely to be binding financially, downstream suppliers are more likely to earn positive profits when financial constraints are binding.

Let us assume that all suppliers have the same initial cash holdings, i.e., $W(m) = W$ for all m. The final-good producer no longer extracts all the quasi-rents from the relationship when the financial constraints are binding, the profit for final-good producer is represented as follows:

$$\begin{aligned}\widetilde{\pi}_F &= \int_0^1 \beta(m) r'(m) dm + \int_0^1 \{W + \kappa[(1-\beta(m))r'(m)]\} dm - \int_0^1 cx(m) dm \\ &= \int_0^1 \left[\beta(m) + (\kappa - \alpha)(1-\beta(m))\right] r'(m) dm + W \end{aligned} \tag{11}$$

Substituting the expressions from equations (3) and (4) into the equation (11) yields,

$$\begin{aligned}\widetilde{\pi}_F = \Theta \int_0^1 & \left[\beta(m) + (\kappa - \alpha)(1-\beta(m))\right] (1-\beta(m))^{\alpha/(1-\alpha)} \\ & \times \left[\int_0^m (1-\beta(j))^{\alpha/(1-\alpha)} dj\right]^{(\rho-\alpha)/(\alpha(1-\rho))} dm + W\end{aligned}$$

where $\Theta \equiv A \dfrac{\rho}{\alpha} \left(\dfrac{1-\rho}{1-\alpha}\right)^{(\rho-\alpha)/(\alpha(1-\rho))} \left(\dfrac{\rho}{c}\right)^{\rho/(1-\rho)}$ is a positive constant.

Proposition 6 *Suppose that Assumption 1 holds, the organizational form $\beta(m)$ is given, and the financial constraints are binding for all stages. Then,*

(i) The final-good producer's profit increases with the level of financial development κ;

(ii) The effect of financial development κ on the final-good producer's profit $\widetilde{\pi}_F$ is stronger especially in downstream stages.

Proof. (i) Differentiating the profit of final-good producer $\widetilde{\pi}_F$ in equation (11) with respect to κ yields the result, i.e., $\dfrac{\partial \widetilde{\pi}_F}{\partial \kappa} > 0$.

(ii) Take the partial derivative of $\widetilde{\pi}_F$ in equation (11) with respect to κ. Then, taking the partial derivative again with respect to m yields the result, i.e., $\dfrac{\partial^2 \widetilde{\pi}_F}{\partial \kappa \partial m} > 0$. ■

The financial development increases the amount of external debt for suppliers. Thus, the final-good producer can extract more upfront transfers from suppliers, mainly from financially binding suppliers. Interestingly, the increasing upfront transfer will bid up the profit for the final-good producer while it decreases the profit for suppliers. Because downstream stages are more likely to be binding, the impacts of financial development are more substantial for the downstream stages.

Next, let us investigate organizational structure when financial constraints are binding for all stages. In the absence of financial constraints, the final-good producer always prefers outsourcing to vertical integration for all stages. However, this is no more the case when the financial constraint is binding. The benefit of choosing the outsourcing disappears as the financial constraint starts to bind because the financial contraint is less likely to bind under vertical integration. Defining

$$v(m) \equiv \int_0^m (1-\beta(j))^{\frac{\alpha}{1-\alpha}} dj,$$

we can write $\widetilde{\pi}_F$ as

$$\widetilde{\pi}_F = \Theta \int_0^1 \left(1-(1-\kappa+\alpha)v'(m)^{(1-\alpha)/\alpha}\right) v'(m) \left[v(m)\right]^{(\rho-\alpha)/(\alpha(1-\rho))} dm + W.$$

Proposition 7 *When financial constraints are not binding for all stages, the optimal orginization structure $\widetilde{\beta}(m)$ is given by:*

$$\widetilde{\beta}(m) = 1 - \frac{\alpha}{1-\kappa+\alpha} m^{(\alpha-\rho)/\alpha}. \tag{12}$$

Proof. Let $\mathcal{L} \equiv \left(1-(1-\kappa+\alpha)(v')^{(1-\alpha)/\alpha}\right) v' v^{(\rho-\alpha)/(\alpha(1-\rho))}$.

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial v} &= \frac{\rho-\alpha}{\alpha(1-\rho)} \left(1-(1-\kappa+\alpha)(v')^{(1-\alpha)/\alpha}\right) v' v^{(\rho-\alpha)/(\alpha(1-\rho))-1}, \\
\frac{\partial \mathcal{L}}{\partial v'} &= \left(1-\frac{1-\kappa+\alpha}{\alpha}(v')^{(1-\alpha)/\alpha}\right) v^{(\rho-\alpha)/(\alpha(1-\rho))}.
\end{aligned}$$

The Euler-Lagrange equation, then, is given by

$$v^{(\rho-\alpha)/(\alpha(1-\rho))}(v')^{(1-\alpha)/\alpha-1}\frac{1-\kappa+\alpha}{\alpha}\frac{1-\alpha}{\alpha}\left[v''+\frac{\rho-\alpha}{(1-\rho)}\frac{(v')^2}{v}\right]=0.$$

As in the proof of Proposition 2, a strictly positive profit for the final-good producer is given by solving the following second-order differential equation.

$$v''+\frac{\rho-\alpha}{(1-\rho)}\frac{(v')^2}{v}=0.$$

Solving the second-order differential equation yields,

$$\begin{aligned} v(m) &= \left(\frac{(1-\alpha)C_1}{1-\rho}(m-C_2)\right)^{(1-\rho)/(1-\alpha)}, \\ v'(m) &= C_1\left(\frac{(1-\alpha)C_1}{1-\rho}(m-C_2)\right)^{(\alpha-\rho)/(1-\alpha)}. \end{aligned}$$

where C_1 is a positive constant and C_2 is a second constant of integration. The initial condition is given by $v(0)=0$ and the transversality condition is $v'(1)^{(1-\alpha)/\alpha}=\frac{\alpha}{1-\kappa+\alpha}$ at the right boundary of the unit interval. Note that the transversality condition is different from the case when the financial constraint is not binding. Using the two conditions, we can obtain $C_1=\left[\frac{\alpha}{1-\kappa+\alpha}\right]^{\alpha/(1-\rho)}\left[\frac{1-\rho}{1-\alpha}\right]^{(\alpha-\rho)/(1-\rho)}$ and $C_2=0$. Plugging C_1 and C_2 into the $v'(m)$ equation, we obtain

$$v'(m)=\left[\frac{\alpha}{1-\kappa+\alpha}\right]^{\alpha/(1-\alpha)}m^{(\alpha-\rho)/(1-\alpha)}.$$

Therefore,

$$\widetilde{\beta}(m)=1-v'(m)^{(1-\alpha)/\alpha}=1-\frac{\alpha}{1-\kappa+\alpha}m^{(\alpha-\rho)/\alpha}.$$

■

Proposition 8 *Suppose that Assumption 1 holds and the financial constraints are binding for all stages. Then,*

(i) $\widetilde{\beta}(m)$ is increasing for all $m \in [0,1]$;

(ii) There exists a unique $m^* \in (0,1]$ such that all stages $m \in [0, m^*)$ are outsourced and all stages $m \in [m^*, 1]$ are vertically integrated.

Proof. (i) If $\rho > \alpha$, then $\dfrac{\partial \widetilde{\beta}(m)}{\partial m} > 0$ for all $m \in [0,1]$.

(ii) From the optimal organizational structure in equation (12), we obtain that $\lim_{m \to 0} \widetilde{\beta}(m) = -\infty$ and $\widetilde{\beta}(1) = 1 - \dfrac{\alpha}{1-\kappa+\alpha}$. Because the final-good producer would choose the minimum possible value of $\beta(m)$, the final-good producer finds it optimal to select outsourcing in the most upstream stage.

If $\beta_v > \beta_o > 1 - \dfrac{\alpha}{1-\kappa+\alpha}$, it is clear that $m^* = 1$ such that all stages will be outsourced. If $\beta_v < 1 - \dfrac{\alpha}{1-\kappa+\alpha}$, then $m^* \in (0,1)$ such that the most downstream stage will be vertically integrated and the most upstream stage will be outsourced. If $\beta_v > 1 - \dfrac{\alpha}{1-\kappa+\alpha} > \beta_o$, then there are two possible cases such that all stages are outsourced $m^* = 1$ or vertical integration and outsourcing coexist along the global value chain $m^* \in (0,1)$. ■

When financial constraints are binding, it is possible that the final-good producer selects vertical integration modes for some stages because the integration alleviates the adverse effects of a supplier's financial constraints. In the vertical integration, the final-good producer requires fewer upfront transfers than the outsourcing. Even though outsourcing allows suppliers to have more incentives for investment, the higher bargaining share for the final-good producer leads them to integrate suppliers vertically. Lastly, the financial constraint affects the most downstream stage suppliers; the final-good producer chooses vertical integration mode from the most downstream stages.

Proposition 9 *Suppose that Assumption 1 holds, the financial constraints are binding for all stages, and vertical integration and outsourcing coexist along the global value chain. Then,*

(i) The increase in financial development κ will expand the range of stages that are outsourced.

(ii) The effect of financial development κ on the bargaining share for suppliers, a decrease in $\widetilde{\beta}(m)$, is stronger especially stages that are far from the most downstream stages.

Proof. (i) Differentiating the optimal organizational structure in equation (12) with respect to κ yields the result, i.e., $\dfrac{\partial\widetilde{\beta}(m)}{\partial\kappa} < 0$.

(ii) Take the partial derivative of $\widetilde{\beta}(m)$ in equation (12) with respect to κ. Then, taking the partial derivative again with respect to m yields the result, i.e., $\dfrac{\partial^2\widetilde{\beta}(m)}{\partial\kappa\partial m} > 0$. ■

The financial development mitigates the problem of financial constraints. Because vertical integration emerges to alleviate the negative impacts of financial constraints, the final-good producer can switch from vertical integration to outsourcing for some stages from the financial development. Since the effects of financial development on the propensity to choose to outsource are more significant when stages are far away from the most downstream stages, stages that are closer to the upstream stages are more likely to switch from vertical integration to outsourcing.

4 Discussion

We next describe how our results apply to optimal sourcing decisions of multinational firms. The multinational firms choose foreign suppliers based on the level of financial development of countries in which suppliers operate and foreign suppliers' production stages. Because multinationals require more upfronts transfers in downstream intermediate inputs, downstream suppliers in financially underdeveloped countries are less likely to meet the financial requirements. Therefore, *downstream intermediate inputs are more likely to be sourced from financially developed countries.*

Concerning the choice of organizational structure, multinational firms would select outsourcing when they contract with suppliers in financially developed countries as outsourcing is optimal when financial constraints are not binding. However, when financial constraints are binding, multinationals would choose vertical integration in order to alleviate the liquidity constraints problem. Moreover, downstream stages are more vulnerable to financial constraints. Hence, *multinationals are more likely to integrate downstream intermediate input suppliers in countries with weak financial institutions.*

Admittedly, our predictions about multinational sourcing strategies depend crucially on two critical parameters in our model: the price elasticity of demand faced by final-good producer ρ and the degree of substitution between the stage inputs α. We have focused our analysis on the sequential complements case $\rho > \alpha$. However, predictions can be reversed if the production process is sequential substitutes $\rho < \alpha$. To determine whether sequential complements or sequential substitutes characterize the production process is an empirical question, and it is beyond the scope of our paper.

5 Conclusion

Building on Antràs and Chor (2013), we provide how credit constraints can affect the property-rights model of the global value chain. We offer new predictions on multinational firms' sourcing decisions that depend on financial development, incomplete contract and different stages of production. Unlike previous studies that find upstream firms need more working capital than downstream firms in the sequential production process because of long delays in payments, we find that downstream stages require more initial working capital so that downstream firms are more likely to be credit constrained.

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