Interdependent product cycles for globally sourced intermediates ☆

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ABSTRACT

We analyze a firm that produces a final good from multiple intermediates, each of which can be sourced domestically or from a low-wage country. Offshoring an intermediate is only profitable when it has matured sufficiently and the savings in production cost outweigh the underinvestment due to incomplete contracts abroad. We derive how equilibrium sourcing decisions of different intermediates depend on one another. In particular, we demonstrate that the maturity threshold to offshore additional parts is higher when some other parts are already sourced from the low-wage country. This prediction is robust to an alternative way of modeling the bargaining process, but it only holds if foreign suppliers are held sufficiently close to their reservation wage. If suppliers are able to capture most of the rents, the prediction reverses. Using information on U.S. imports of automotive parts, we illustrate that for most countries the price at which they first export a part tends to be higher for parts that are only exported later, consistent with offshoring becoming gradually more difficult.

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1. Introduction

International trade in intermediate inputs has become very important. Between 1970 and 1990 the share of imported intermediates in the value of exports increased by one third (Hummels et al., 2001) and by 2004, local value added accounted for only 40 to 47% of national exports (Johnson and Noguera, 2012).[1] Because input demand derives from the production function, intermediate goods trade has some distinct features from trade in finished products.

While demand for final goods is almost always modeled as constant over time, technological change will influence demand for intermediates through the production process. Undoubtedly, this affects different intermediates to a different extent or at a different pace. Moreover, sourcing decisions for different intermediates are only independent under very restrictive assumptions. A change in the marginal cost of one part, for example because it is offshored, will generally influence the demand for other parts that are installed in the same final good. This, in turn, influences their optimal sourcing. Both direct substitution between parts in production and indirect effects from the change in marginal cost and equilibrium output of the final good play a role.

Product cycle models provide a useful framework to study the integration of low-wage countries into global value chains. As highlighted in Vernon (1966), products often display a natural cycle. They are first produced where they are developed, usually in high-wage, more developed economies. Only after their design has been fixed and manufacturing standardized does production shift to low-wage countries. Profitably producing in a low-wage country requires a minimum level of maturity such that the cost savings in production are sufficient to overcome trading or other frictions. In the case of intermediates, these sourcing decisions will be interrelated as argued above. The specific question we ask is how the minimum maturity level needed to profitably offshore one part depends on the offshoring decisions of other parts. More sophisticated and skill-intensive parts that mature only slowly will typically be offshored later. What we study is whether they are offshored earlier or later in their own product cycle, i.e. at lower or higher maturity level.

Our model is closest to Antràs (2005) where the incompleteness of contracts in the low-wage country (South) is the friction that keeps

[1] With the publication of the World Input–Output Database, see Timmer (2012), many more studies have started to document the international fragmentation of production. Our analysis helps to understand the equilibrium (global) input–output structure and how it changes over time. In particular, we will highlight sources other than comparative advantage in production that help shape observed sourcing patterns.

production of less mature products in the high-wage country (North). Weaker institutions make it impossible to contractually specify supplier investment and the firm and supplier will bargain over the surplus from their relationship. The resulting underinvestment in specific inputs makes production in South only profitable for products where the input of the supplier has become sufficiently important. In Antràs (2005), each firm produces a single product along a continuum and makes an independent offshoring decision. We introduce multiple intermediates in the model and the final good producer decides the sourcing location for all of them. Offshoring decisions of different intermediates are now naturally related. In particular, the maturity threshold—the point in an intermediate's product cycle where the firm is indifferent between sourcing in North or South—is no longer a constant, but a function of the production locations and maturity levels of other intermediates installed in the same final good.

The property rights model is a popular framework to study offshoring, but in most models outsourcing decisions are made for each product independently (Antràs and Helpman, 2004; Feenstra and Hanson, 2005; Grossman and Helpman, 2005). The model in Spencer and Qiu, (2001) does feature multiple inputs, but without any interaction between outsourcing decisions. Sourcing decisions for different products do interact in the model of Acemoglu et al. (2007), but only through their dependence on aggregate output, which is increasing in the total number of intermediates, interpreted as the level of technology. In the product cycle literature, a few papers incorporate other types of general equilibrium interactions with symmetric effects on all products.[2]

Two recent papers explicitly study interdependencies in supply chain choices in an incomplete contracting framework.[3] Antràs and Chor (2013) look at the make-or-buy decision for different intermediates, but they fix the sequencing of intermediates in the supply chain. The integration decision at each production step depends crucially on the part's position along the chain and on the demand elasticity of the final product. Schwarz and Suedekum (2014) consider a continuum of input tasks and study simultaneously how to partition the space into a finite set of parts, whether to produce parts in-house or not, and whether to source domestically or abroad. In their model the firm's own productivity plays a key role, for example it increases the share of foreign outsourcing, but the set of tasks is fixed.

Our main finding is that intermediates that mature slowly and are offshored late will face a higher equilibrium maturity threshold. Parts that are only offshored when other, fast-maturing parts are already sourced from South require a higher maturity level before they can be profitably sourced from South themselves. This is the net effect of two opposing forces. First, the greater difficulty of substituting between intermediates than between final goods mitigates the underinvestment problem and facilitates offshoring. Second, when production involves incomplete contracts, the final good producer needs to bargain with South supplier(s) over the surplus. Net revenue is less elastic and the firm chooses a higher-price and lower-quantity point on the demand curve, raising the ratio of revenue to variable cost. It exacerbates the underinvestment problem and makes offshoring additional intermediates more difficult. The first effect is approximately the same for all intermediates and it dominates for parts that mature early. The second effect becomes more important when many intermediates are already sourced

in South and dominates for parts that mature late. Compared with a model with only final goods, offshoring a first part is already profitable at a lower maturity level, but the maturity threshold is higher for each additional part.[4]

We verify the robustness of this finding in two extensions. First, we generalize a simplifying assumption in the bargaining process, the final stage of the model. Rather than use a series of bilateral bargaining games between the firm and each individual supplier, we model the process of ex-post rent division as a single multilateral bargaining game between the firm and all suppliers simultaneously. This change strengthens the main prediction.

Second, we eliminate ex-ante payments from the first stage of the model. In the benchmark case South suppliers compete to be selected. Even though they receive some surplus in the final stage, they only earn the reservation wage in equilibrium as the final good producer can extract any potential surplus from the relationship with an ex-ante payment when suppliers are selected. The size and even the direction of this payment depend on the outside option of the final good producer, but the equilibrium sourcing decision does not. However, if suppliers are scarce and cannot be held to their reservation wage, they will capture some of the rents. Now the firm's exact outside option will matter for equilibrium. If the outsourcing firm has a sufficiently weak bargaining position, it is even possible that the interdependency between parts reverses. In such a case, the maturity threshold is lower when other intermediates are already produced in the low-wage country. Offshoring one part makes it easier to offshore additional parts.[5] Antràs and Rossi-Hansberg (2009) have argued that theoretical insights in this literature can depend crucially on the modeling assumptions for the organization of production and this extension provides a good illustration.

The static model can be given a dynamic interpretation, as in Antràs (2005), by supplementing it with an evolution of the vector of maturity levels of all parts. This generates a succession of static equilibria that traces out a product cycle for each part. In this dynamic interpretation, the finding in the benchmark model implies that offshoring is slowing down. If intermediates mature at a constant rate, it will gradually take longer and longer to offshore each additional intermediate. Over time, parts need to achieve ever higher levels of maturity (low-skill input intensity) before production in the low-cost country becomes profitable.

News reports sometimes claim that the process of international outsourcing is accelerating; that nowadays production already switches to low-cost destinations before products mature very much. Supply side effects of earlier offshoring decisions could trigger such a process. Accumulation of production experience in South could raise the local productivity level or the ability to enforce contracts, enhancing offshoring incentives. General equilibrium effects, however, are likely to go in the opposite direction as increased production in South raises local wage levels and lowers offshoring incentives (Egger et al., 2013).[6] Our contribution highlights a direct, partial-equilibrium effect that works through the demand side. For intermediate inputs, which make up a growing share of global trade, the demand side provides a natural connection between the optimal sourcing decisions of different goods.

To illustrate the empirical relevance of our prediction, we compare the patterns of U.S. automotive part imports from different countries.

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[2] Krugman (1979) and Dollar (1989) embed a product cycle in a general equilibrium framework where wages, and thus the incentive to offshore, are endogenous. Grossman and Helpman (1991) derive the rate of new product introductions and the speed of maturing as a function of innovation parameters.

[3] Two other models study interdependent outsourcing decisions, but in very different contexts and using different modeling approaches. Baldwin and Venables (2013) contrast snake-like value chains, where adjacency is crucial, and spider-like chains with final assembly of dispersed parts. The offshoring process can unfold quite differently for both types of chains, but few general results can be derived. The need to disclose sensitive business information or to coordinate production decisions generates a direct complementarity between outsourcing decisions of different intermediates in Novak and Stern (2009).

[4] The threshold even increases in the maturity level of intermediates that are already produced in South.

[5] An alternative model in the online Appendix IV without contracting frictions but with an exogenous fixed cost of offshoring has the maturity thresholds monotonically decreasing in the number of intermediates already offshored and in their maturity. The incomplete contracting model without ex-ante payments has this outcome as a possibility if the firm's bargaining option is sufficiently weak.

[6] In addition to the feedback through wages, (Doh, 2005) also mentions rising environmental standards. In the trade-in-tasks framework of Grossman and Rossi-Hansberg (2008), offshoring one task similarly changes equilibrium factor prices, productivity, and labor supply, and influences optimal sourcing of other tasks through general equilibrium effects.