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Re-Evaluating the ‘Smile Curve’ in Relation to Outsourcing Industrialization

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ABSTRACT

In this paper, we argue that the widely used concept of the value-added driven ‘smile curve’ in the international business literature, which often illustrates a zero-sum game between interdependent nations in the global supply chain, requires revisiting. In particular, the U-shaped smile curve for the distribution of profitability among partners can be inverted if firms from the developing economies manage to obtain high productivity from their workers and have no high entry costs to the midstream industries that specialize in global supply chains. We construct an economic model and find that the theories proposed in the paper are broadly consistent with the empirical evidence. Our findings have some important implications for the current debate on industrialization strategies with particular reference to outsourcing industrialization for developing countries.

KEYWORDS

Industrialization strategies; smile curve; labor productivity; entry cost; economic development

JEL CLASSIFICATION

F12; F23; F60; and L14

1. Introduction

The division of gains from global international trade has been widely discussed in the literature (Markusen 1981, 1984; Markusen and Melvin 1981; Krugman 1981; Kemp and Wan 1986; Baldwin 1992; Arndt 1998; Devereux and Lee 2001; Melitz and Trefler 2012; Meltiz and Redding 2014; Arkolakis et al. 2008; Edmond, Midrigan, and Xu 2015; Feenstra 2018). These writers on the division of the gains from trade are mainly divided into 3 categories following Melitz and Trefler (2012), as follows: (1) advocates of the New Trade Theory based on intra-industry trade in the differentiated goods produced subject to increasing return to scale (Krugman 1981; Markusen 1981, 1983; Markusen and Melvin 1981); (2) advocates of the firm level “reallocation” effect under the heterogeneous firm framework (Melitz 2003; Meltiz and Redding 2014); and (3) supporters of the positive impact of larger markets on innovation (Aw, Roberts, and Xu 2011; Grossman and Helpman...
1991; Verhoogen 2008). Nonetheless, with the rising level of economic globalization, the distinguishing feature of global trade has since the 1990s gradually been transformed from trade in final goods to vertical disintegration with reference to the intermediate input trade. Surprisingly, the gains from such vertical production trade at the global level have seldom been explored in the literature. The aim of this paper is to make one of the first attempts to theoretically investigate how the gains are distributed under the global vertical production network and to outline the implications of this for the industrialization strategies of developing countries.

Several terms have been used to refer to the new global vertical production pattern, ranging from ‘vertical specialization’ (Yi 2003) to ‘the unbundling of production’ (Baldwin 2013). The essence of this new global production pattern is that previously unseparated production processes in a single location are now subject to ‘parts componentization’ across countries. For example, in the semi-conductor industry, key components, research and development are the work of the US or Japan, whereas the components themselves are assembled in low wage countries such as Mexico or China.

At the micro-level, fragmented production is portrayed by a ‘smile curve’, a well-known concept in the management literature. According to the smile curve, an international supply chain is divided into three parts: upstream, which specializes in research and development (R&D); midstream, which concentrates on assembly; and downstream, which takes care of sales and services (Mudambi 2007, 2008; Shih 1996; Ye, Meng and Wei 2015). It has been asserted that the upstream and downstream firms generate higher value added than their midstream counterpart (Baldwin et.al 2014) (see Figure S1).

The natural implication derived from the U-shaped smile curve is that the firms specializing at the two ends of a global supply chain (the R&D and Marketing stage) will also be more profitable than firms specializing at the midstream stage. Hence, from the policy point of view, the only way for a developing country to catch up with the developed economies is to encourage firms to upgrade along the global supply chains, climbing from the midstream assembly stage to the R&D or Marketing stages with a view to becoming more competitive and profitable. The main contribution of the present paper is that we propose a theoretical model to illustrate the relevance of other patterns of smile curve, which have not been studied previously.

However, two critical issues first require attention, before assessing the policy implications of the smile curve. First, the smile curve is measured only by the distribution of value-added along the supply chains, while it has been recognized that the U-shape of the smile curve is not in fact universal, though once supposed so. According to Baldwin (2012), the smile curve was flatter in the 1970s, because the gains by the chain partners were
relatively equal. The participation of developing economies has made the smile curve deeper and more concave (see Figure S2). Baldwin (2012) argues that it has changed shape because the productivity gap after the 2000s between firms from developing countries and those from developed countries became much greater than the gap in the 1970s. In order to capture this productivity gap effect, our theoretical model introduces a heterogeneous firm framework by assuming that the labor productivity of firms varies across different stages in the chains and therefore one can detect the channel through which labor productivity plays a role in affecting the dynamics of the distribution of profitability along the supply chains.

Second, a firm’s value-added is not conceptually equivalent to its profitability, but so far neither empirical nor theoretical work has begun to assess the validity of the smile curve on the basis of measuring the profitability index. Rungi and Del (2018) implemented a firm-level test to empirically assess the validity of the smile curve, but their test is still based on the value-added shares of each stage in the chains. The major difference between profitability and value added is that the value added takes no account of the way in which the cost effect shapes the profitability of a firm. One of the contributions of the theoretical model proposed in the present paper is that, assuming a heterogeneous firm framework, we incorporate the entry cost effect into the model and allow the entry cost to vary with the different production stages along the chains. As a result, the ways in which the dynamics of entry costs along the supply chains affect the profitability distribution along the chains can also be illustrated.

More interestingly, the gains among supply chain partners may be flat but may equally be in an inverted U shape, or a ‘grieving curve’. We use firm-level data from the Wind Information, first to estimate the dynamics of profitability along global industry chains of two types – for the shoe and the car industries (see Figure S3). On the vertical axis, we use the average inverse value of the profit-earnings ratio (P-E ratio) from 2012 to 2016 as proxy for the profitability of the firms in the chains. In corporate finance, the inverse value of the profit-earnings ratio is equivalent to the earning yield for a listed firm. A higher inverse value of the P-E ratio implies that the firm is earning more. The horizontal axis represents the production stages. Our estimation implies that the distribution of profitability along the global car industry chain exhibits the inverted U-shaped form in which the midstream firms are much more profitable than the firms specializing at the two ends of the chain.

One of the purposes of this paper is to argue that an inverted U-shaped curve may occur among the partners of a chain. That is to say, it is not necessarily the case that the developing countries that specialize in the midstream stage in the chain could not benefit from the global production pattern of manufacturing outsourcing as a midstream operation. The direct implication of such an inverted U-shaped curve regarding the profitability distribution along the supply
chains is that developing countries could succeed in industrializing themselves by undertaking activities in the midstream manufacturing stage that developed countries could outsource. In this paper, we call such a process of industrialization ‘outsourcing industrialization’.

Second, our paper also derives the condition under which such outsourcing strategies could be effective in making the midstream firms from the developing countries more profitable than the upstream or downstream firms from the developed countries. We demonstrate in a theoretical model that there are two essential conditions for outsourcing industrialization to work: (1) the labor productivity of the firms in the midstream stage must exceed that of the firms in the upstream and downstream stages in the supply chain; and (2) the entry costs faced by the firms in the midstream stage must be strictly lower than those faced by the firms in the upstream and downstream stages in the supply chains. From the previous empirical evidence, we have shown that the global car industry is an example. The TRW-automotive company which specializes in car reassembly in the midstream production stage is characterized by high labor productivity and brings high returns. Second, it could be the case that the entry costs for the upstream and downstream stages of the two ends of the car industry chain are higher than for the midstream manufacturing stage. In contrast, the Stella International holding company as a shoe manufacturing company is not as profitable as those which specialize in the design and marketing stages at the two ends of the chain. Our hypothesis is that the labor productivity of a midstream firm in the shoe industry is not as high as that of companies specializing at the design or the marketing stage.

The reason for choosing labor productivity and the entry cost level of a particular production stage as the two key factors in determining the success of one country’s outsourcing strategy is mainly that, according to Altenburg (2006), Kaplinsky (2000, 2004), Gereffi and Kaplinsky (2001) and Gibbon (2003), the ex-ante entry cost of inserting a firm in certain segments of a supply chain is the key to determining whether some firms could be competitive and the extent to which they could extract rents. Using a case study from Kaplinsky (2000, 2004) illustrated the fact that the low cost of workers’ wages, as part of the entry cost faced by firms in China, enabled firms to insert themselves easily into the labor-intensive production stages in the global supply chains, which turned firms from China into the dominant suppliers in the chains for the capital-intensive firms from the West. Gibbon (2003) uses the global fresh fruit and vegetable chain as a case study to analyze how the entry barriers in the fresh fruit and vegetable industry matter for the distribution of profitability along the chain. Analogously to the argument of entry cost, Gereffi, Humphrey, and Sturgeon (2005) propose that the capabilities in the supply-base form a fundamental factor in determining how firms can upgrade along the supply chains. The term ‘capabilities in the supply base’ refers to the possibility that particular production stages (or industries) in the supply chains could productive enough to sustain the competitiveness
of the firms involved in the chains. Hence, it becomes obvious that the labor productivity of the industries in the supply chains is also crucial for the sustainable competitiveness of the firms operating within these industries. Our paper theorizes these arguments and demonstrates in a hierarchy assignment model that developing countries initially specializing in low value-added midstream assembly in the chains can succeed in enhancing their industrial capabilities but only if firms from these countries enter into industries that enjoy high labor productivity and low entry cost. Once firms enter these industries, they can overcome the low-value added disadvantages of the midstream assembly stage by their low cost structure and high profit margin.

The profitability-based smile curve has several advantages for those assessing the competitiveness of a nation which engages in trade in the global supply chains trade compared with the value-added based smile curve, which is normally discussed in the literature. First, a firm’s profitability is the direct measure of its economic performance and therefore the high profitability of the individual firm forms the micro-level foundation for estimating the degree of competitiveness of a country’s industrial capability. That is to say, if each individual firm in a country specializing in a particular production stage of the chains earns higher profits than their counterparts in other countries producing at other production stages, it follows that countries having more profitable firms will be more dominant and competitive within the global supply chains than other countries regarding their industrial capability. Therefore, a smile curve based on the distribution of profitability along the global supply chains could well reflect such an asymmetrical distribution of power relations and industrial capabilities among the various countries involved in the trade. Second, the profitability-driven smile curve can disentangle the negative effect of cost structure on firms’ performance, whereas the value-added smile curve fails to do so. That is to say, it is sometimes very misleading to assess the competitiveness of a firm on the basis of value-added only. It should also consider the level of cost that the firm has to incur so as to generate a certain profitability. Some firms may have very high value-added, or they might simply incur such high capital or labor costs that they failed to make a profit. For instance, as Wu (2003), Li, Liu, and Wang. (2015) and Shen, Tang, and Chow (2018) argue, firms specializing in high-value added upstream sectors in Chinese industry chains are not as profitable as the downstream low-value added firms. The same logic applies to global industry chains. The reason for the appearance of the inverted U-shaped profitability smile curve is largely because some supply chains, such as those in the upstream and downstream sectors where firms specialize in occupying high value-added stages, entail very high costs, including those for both labor and capital. Hence, the larger component of the cost within the total value added generated by these sectors leads to a situation in which the firms specializing in these high value-added sectors are not necessarily as profitable as those producing in the low-value added sectors. From this perspective, it becomes more reasonable for
countries to decide to participate in certain parts of global supply chains according to the potential level of profitability that these production stages could generate and the corresponding costs entailed, rather than the level of value-added that they could extract. Second, a profitability driven smile curve is the direct reflection of the division of the gains among the inter-connected nations around the globe. According to Melitz (2003), only the most productive firms export and therefore the profitability of exporting firms from each country specializing within the supply chains measures the competitiveness of the industrial capability of the countries concerned. If firms at a particular production stage are more profitable, then this indicates that the countries within which these firms operate have achieved higher levels of industrial capability. The converse about the effect of low-profitable firms in the supply chains also holds.

The rest of the paper is organized as follows: Section 2 contains the literature review, Section 3, the model solving, Section 4 presents the empirical evidence and the concluding remarks are offered in Section 5.

2. A Literature Review

2.1. Industrialization and Economic Development

Our paper stands at the intersection between two streams of literature, i.e. economic industrialization and global supply chains. In the literature on late development and industrialization, the paper by Murphy, Shleifer and Vishny proposes the idea of so-called big push industrialization (Murphy, Shleifer, and Vishny 1989). They argue that the only way for developing countries to succeed in industrialization is through the modernization of every sector in their economy. In other words, the economy should contain no multiple equilibria, meaning that if one sector modernizes, then the other sectors must also modernize. The weakness of their view is that their theory relies on the assumption of a closed economy, ignoring the possibility of a country’s participation in the external global trade system. Given an open economy, it is impossible for every sector of a country to be competitive in the international market and therefore some specific industries have to be targeted so that they can compete with their counterparts at the international level. Our paper strengthens this weak point, arguing that since global trade is driven by the supply chain, developing countries should promote the industries that have high labor productivity but lower entry cost. Second, our paper differs from the work of the three authors above in the sense that they do not consider the inter-connectedness of the various sectors, whereas the analysis in our paper incorporates the vertical production structure of the trade.

Moreover, our paper is in line with the spirit of work by Baldwin, Martin, and Ottaviano (2001). In their paper, they devise in the context of an open economy a stages-of-growth model showing how the South (the developing
countries) can catch up with the North (the developed countries) at the global level if trade costs fall. Our paper partially agrees with their view, in the sense that trade liberalization with a reduction in trade costs could enhance the economic development of the South, but they do not go on to ask how a developing country should choose its industrial development strategy after trade liberalization reforms. Unlike them, we raise the question ‘After a developing country has instituted trade liberalization, what kind of productivity and cost conditions could the manufacturing production stage offer as a result of participating in the midstream manufacturing stage in the global supply chain that would make these midstream firms become most profitable in the global supply chains?’

Another paper by Sutton and Trefler (2016), which relates the global trade to a nation’s industrial development strategy, is also worth mentioning. In this paper, they demonstrate a Ricardian-sorting type general equilibrium model to show that an inverted U-shaped pattern links a country’s export mix with its GDP income per capita. The difference between our paper and theirs is that they consider how the wealth of a country or the profitability of a firm is affected by its export mix or capability (quality and productivity), whereas in our framework the labor productivity and entry cost are the two factors that are treated as sources of the gain from trade.

2.2. Global Supply Chains

Our paper is likewise associated with the literature that focuses on the unequal distribution of gains between countries engaged in global trade (Costinot and Vogel 2010; Costinot, Vogel, and Wang 2013; Basco and Mestieri 2014). For instance, the paper by Costinot and Vogel (2010) and the other by Costinot, Vogel, and Wang (2013) both illustrate the fact that wage inequality characterizes the global supply chains. Nonetheless, they do not ask why such wage inequality can occur there; we, however, do ask this question and go on to argue that wage inequality may be endogenous to the distribution of heterogeneous labor productivity along the supply chains.

Similarly, the paper by Sergi and Mestieri (2014) also brings out the point that the unbundling of production generates income divergence among ex-ante identical countries. With heterogeneous countries, it increases top-bottom inequality and it has non-monotonic effects on the world’s income distribution (it reduces the income share of middle-productivity countries more than that of others). Regarding the welfare implications of production unbundling, they also document the fact that when the South joins the global supply chain, the combined income share of the Northern and the most productive Southern countries rises, at the expense of the least productive Southern countries. Although their paper notes that a developing country (a Southern country) may benefit from participating in the unbundling production system at the
global level through the convergence of the income effect, they focus only on the exogenous income effect and do not further investigate how such an income effect can be endogenous to the distribution of labor productivity along the supply chains. According to our paper, the benefits from joining the global supply chains must be endogenous to some particular industrial characteristics that make the Southern countries most productive. We argue that such a catching-up effect between Southern and Northern countries depends on whether a Southern country can enter the production stages in the chains that are typified by high labor productivity and low entry cost.

A paper by Rodrik (2018) nevertheless argues that, due to the introduction of new technologies, global value chains (GVCs) exhibit features that limit the upside and may even undermine the economic performance of developing countries. In particular, GVCs have two channels for constraining the productivity of developing countries. First, they reduce the comparative advantage of developing countries in traditionally labor-intensive manufacturing (and other) activities and diminish their gains from trade. Second, GVCs make it harder for low-income countries to use their labor cost advantage to offset their technological disadvantage, by reducing their ability to substitute unskilled labor for other production inputs. Our paper partially agrees with these views, because some losers will undoubtedly result from the GVCs if developing countries enter into the midstream manufacturing industries while they still have low productivity and face high entry costs. In particular, the introduction of new technologies by developed countries widens the technological gap between developing and developed countries and also raises the cost for firms to enter some production stages. However, Rodrik’s paper does not incorporate in its analysis the concept of the heterogeneity of industries, which means that the type of supply chain may matter to the division of the gains among the interdependent nations. That is to say, if some midstream manufacturing stages have high labor productivity and low entry costs, such as the labor-intensive industry chains for shoes, clothes and so on, it might be possible for developing countries to use their comparative advantage in terms of lower labor costs.

A paper by Taglioni and Winkler (2016) illustrates the value of enhancing a nation’s development goals through participating in global GVCs. It argues that although GVCs could create a demand for unskilled workers in the developing countries, it might not work if the supply side of the labor market in these countries was absent. That is to say, some external policies for increasing the absorptive capacity of firms from developing countries, including their physical and regulatory infrastructure, should upgrade labor skills in order to make the effect of the GVCs more beneficial. Our paper partially agrees that whether or not a nation can benefit from entry into a GVC depends upon the external developmental policies that it adopts. However, our paper strongly
supports the view that these developmental and industrial policies should target particular industries that might participate in the GVCs.

2.3. The Profitability-driven Smile Curve and Its Relation to Countries’ Participation in the Global Production Network

The profitability-driven implications of the smile curve, together with its relation to a country’s participation in the global production network can be found in some of the recent literature in international business and international trade. For instance, as argued by Baldwin and Lopez-Gonzalez (2015), the global production network has witnessed the dominance of supply-chain driven trade. In this situation, countries are increasingly inter-connected, raising the question of which whom will benefit more from such new forms of trade. As illustrated by Baldwin (2014), the second unbundling of international production illustrated by the smile curve has created winners and losers at the stage-of-production level rather than at the sector level. He further proposes that the stages relating to the fabrication of goods have been systematic losers for the rich nations and systemic winners for the emerging markets. In rich countries, the trade winners tend to be pre-and post-fabrication services such as design, marketing, after-sales services and so on. Although Baldwin’s work on the economic implications of the smile curve gives a comprehensive picture of the way that supply-chain driven trade creates losers and winners in the global production network, his definition of the smile curve is still based on value-added rather than profitability. This could be misleading, because it is inconsistent with the stylized facts that some firms from emerging markets specializing in fabrication services, such as Foxconn, could be as profitable as the US Apple company, which specializes in pre and post fabrication services in the chains. That is to say, although firms from rich nations can produce very high value-added in the pre- or post- fabrication services in the chains, they also have to pay very high costs including those for both capital and labor. This may not necessarily lead to high profitability for all the firms from a rich nation in the supply-chain trade. Equally, firms from emerging markets producing in the low-value added stages, may produce higher net profitability, due to their low labor and capital costs, than do firms from rich nations in the supply chains.

One of the natural implications deriving from a profitability-driven smile curve is that, in contrast to the argument proposed by Baldwin (2012) who claims remaining in the manufacturing stage in the supply chain may not be the developmental panacea allowing a late-comer country to industrialize, our paper demonstrates that it could still be profitable for firms to specialize at the midstream assembly stage and therefore provides a rationale for developing countries to adopt the industrialization strategy of supplying outsourced manufacturing to firms in rich countries.
3. Model

3.1. Set Up

In line with the spirit of a hierarchy assignment model developed by Lucas (1978); Rosen (1982); Kremer (1993); Garicano and Rossi-Hansberg (2004, 2006), we develop a theoretical model which incorporates the heterogeneous firm framework into the context of sequential production (Antras and Chor, 2013; Costinot, Vogel, and Wang 2013). It is assumed here that a supply chain is made up of three stages (upstream, midstream and downstream). In our paper, the upstream stage is exclusively for research and development; the midstream stage is for assembly/manufacturing; and the downstream stage is for marketing and services. The $i$th production stage is indexed by $i$ as follows:

\[
\begin{align*}
&\text{Research and Development (Upstream stage)} \quad \text{if } i = 1 \\
&\text{Assembly (Midstream stage)} \quad \text{if } i = 2 \\
&\text{Marketing (Downstream stage)} \quad \text{if } i = 3
\end{align*}
\]

Each stage consists of $n_1$, $n_2$ and $n_3$ firms and therefore each stage takes the form of monopolistic competition. The production function for a representative firm at production stage $i$ takes the Cobb-Douglas form: $q_i = (L_i)^{\alpha_i}$ where $\alpha_i > 1$ implies increasing returns to scale.\(^6\)

The demand for the labor of a representative firm at production stage $i$ is characterized as follows: $L_i(q_i) = (q_i)\lambda l_i$ where $\lambda$ is a positive parameter ($\lambda > 1$). $l_i$ is the inverse value of labor productivity at stage $i$, namely $l_i = L_i / q_i$.

We incorporate joint-contracting choices with a sequential flow of intermediate input to resolve the problems of double marginalization and lower joint-profitability caused by the complex vertical production structure through vertical restraint, so-called ‘quantity fixing’ (Bernard and Dhingra 2015; Hart et al. 1990; Rey and Verge 2004). Another interpretation of the quantity fixing vertical restraint contract is that we allow an exclusive dealing relationship between two vertically-linked firms such that the business stealing effect can be eliminated. This is because each production stage has a different number of firms and the profit sharing between two vertically-linked firms is inevitably affected by their respective competitors in the production stage. The competitors of each firm may steal some of its profits, which makes it difficult to study firm-level profit-sharing along the global supply chains. The introduction of a quantity fixing vertical restraint is to specify the bilateral contract made by the upstream firm such that there is only one upstream firm selling certain outputs to a given midstream firm and one midstream firm selling to a given downstream firm. Such bilateral contracts fixing the quantity rule out the effect of varying the market structure of each production stage on profit-sharing along the supply chains. Taking everything into account, we propose the first assumption in our paper:
Assumption 1: Ex-post outputs in all stages are equal \( q_1 = q_2 = q_3 = q^* \), where \( q^* \) is the fixing quantity imposed by the upstream firm.\(^7\)

Assumption 1 is also in line with the spirit of skill clustering proposed by Kremer’s O-ring theory (1993). According to Kremer (1993), one of the key assumptions for sequential production is that one must ensure skill sorting such that only productive firms transact with other productive firms. Since our paper considers the framework of sequential production, it is reasonable to make the above assumption (Assumption 1).

Furthermore, this idea of fixing quantity is that it is the first-best ex-post output that can maximize the joint profits of all the firms producing along the supply chains. In other words, \( q^* \) is the unique solution which solves the following problem:

\[
q^* = \arg\max_{q_i} \sum_{i=1}^{3} p_i q_i - w_i L(q_i) - F_i(q_i)
\]

Similar to Shen, Tang, and Chow (2018), we assume the imposition of entry costs at each production stage. The weight of the entry cost varies across production stages. For instance, the entry cost for an upstream partner in the telecommunication and miming sectors can be much greater than for its mid-stream counterparts. High entry cost may be canceled by labor productivity. If so, the U-shape curve remains. If not, the curve may flip over and become an inverted U. Our position draws support from several empirical studies. One of the papers by Shin, Kraemer, and Dedrick (2012) shows that the U-shaped relationship between profitability and the production stage becomes ambiguous when the high entry costs at the two ends of the curve are taken into account.

### 3.2. Firm-level Division of the Gains in Global Supply Chains

A representative firm at stage \( i \) faces the following constrained maximizing problem:

\[
\underbrace{\max_{q_i} \pi_i(q_i)}_{q_i} = p_i q_i - w_i L(q_i) - F_i(q_i)
\]  \hspace{1cm} (1)

\[
s.t \; L_i(q_i) = (q_i)^\lambda l_i,
\]  \hspace{1cm} (2)

\[
q_i = (L_i)^{\alpha_i}
\]  \hspace{1cm} (3)

where \( \pi_i \) is the profit function of the firm at stage \( i \); \( w_i \) is the wage level at stage \( i \). \( F_i(q_i) \) is the entry cost function for stage \( i \). (2) is the exponential
functional form for the labor demand function of the firm at stage $i$. (3) is the production function of the firm at stage $i$. This functional form of labour demand is in line with the spirit of Dalamazzo et al. (2007).

To maximize the profit by a firm at stage $i$, we take the derivative of ex-ante quantity $q_i$ on both sides and make it equal to zero, hence:

$$\frac{d\pi_i(q_i)}{dq_i} = p_i - w_i \frac{\partial L(q_i)}{\partial q_i} - \frac{dF_i(q_i)}{dq_i}$$

(4)

and

$$p_i = w_i \frac{\partial L(q_i)}{\partial q_i} + \frac{\partial F_i(q_i)}{\partial q_i}$$

(5)

Plugging (2) into (5), we obtain

$$p_i = w_i \lambda(q_i)^{\lambda-1}l_i + \frac{\partial F_i(q_i)}{\partial q_i}$$

(6)

Plugging in the fixing quantity imposed by the upstream firm into (6), thus

$$p_i = w_i \lambda(q^*)^{\lambda-1}l_i + \frac{\partial F_i(q^*)}{\partial q_i}$$

(7)

Since the entry cost is given at the fixing quantity, $\frac{\partial F_i(q^*)}{\partial q_i} = 0$; the price charged by a firm at stage $i$ is $p_i = w_i \lambda(q^*)^{\lambda-1}l_i$

Now, dividing (1) by $q^*$ on both sides to obtain the average profit:

$$\frac{\pi_i(q^*)}{q^*} = p_i - w_i \frac{L(q^*)}{q^*} - \frac{F_i(q^*)}{q^*}$$

(8)

Plugging (7) into (8):

$$\frac{\pi_i(q^*)}{q^*} = w_i \lambda(q^*)^{\lambda-1}l_i - w_i(q^*)^{\lambda-1}l_i - \frac{F_i(q^*)}{q^*}$$

(9)

Re-writing (9) as the following:

$$\frac{\pi_i(q^*)}{q^*} = (1 - \lambda)w_i(q^*)^{\lambda-1}l_i - \frac{F_i(q^*)}{q^*}$$

(10)

According to (10), the average profit function of a firm at stage $i$ has two effects: (1) the ‘Average Product of Labor Effect’; and (2) the ‘Entry Cost Effect’:

$$\frac{\pi_i(q^*)}{q^*} = \left(1 - \lambda\right)w_i(q^*)^{\lambda-1}l_i - \frac{F_i(q^*)}{q^*}$$

(11)
**Proposition 1:** The average profitability of an upstream or downstream firm is higher than its midstream counterpart so the U-shaped profitability-driven smile curve becomes valid if and only if the labor-productivity gap effect dominates the entry cost gap effect.

\[
\frac{w_1 (q^*)^\lambda - 1}{(L_1)^{a_1 - 1}} - \frac{w_2 (q^*)^\lambda - 1}{(L_2)^{a_2 - 1}} > \frac{F_1(q^*)}{q^*} - \frac{F_2(q^*)}{q^*}
\]

Productivity gap effect

\[
\frac{w_3 (q^*)^\lambda - 1}{(L_3)^{a_1 - 1}} - \frac{w_2 (q^*)^\lambda - 1}{(L_2)^{a_2 - 1}} > \frac{F_3(q^*)}{q^*} - \frac{F_2(q^*)}{q^*}
\]

Productivity gap effect

**For the Proof of Proposition 1, please see the Supplementary Material, available online.**

Proposition 1 implies that as long as the difference in labor-productivity between two vertically-linked firms strictly dominate the differences in the entry cost faced by these two vertically-linked firms, then the U-shaped form of the smile curve will emerge. In order to validate the inequality implied by Proposition 1, it has to be the case that the labor productivity for the midstream firm must be sufficiently small and the entry cost faced by the midstream firm must be sufficiently large. If the Productivity Gap Effect is overwhelmed by the Entry Cost Gap Effect, the profitability curve becomes an inverted U-shaped 'grieving curve'.

This leads to Proposition 2.

**Proposition 2:** The profitability-driven smile curve takes an inverted U shape when the labor productivity gap is strictly dominated by the entry cost gap:

\[
\frac{(1 - \lambda)}{w_1 (q^*)^\lambda - 1} - \frac{(1 - \lambda)}{w_2 (q^*)^\lambda - 1} < \frac{F_1(q^*)}{q^*} - \frac{F_2(q^*)}{q^*}
\]

Productivity gap effect

\[
\frac{(1 - \lambda)}{w_3 (q^*)^\lambda - 1} - \frac{(1 - \lambda)}{w_2 (q^*)^\lambda - 1} < \frac{F_3(q^*)}{q^*} - \frac{F_2(q^*)}{q^*}
\]

Productivity gap effect

**entry cost gap effect**
The proof of Proposition 2 is similar to that of Proposition 1.
Proposition 2 shows that in order for firms to sustain higher profitability in the midstream of the production stages of the supply chains, two conditions must hold: (1) the midstream firm must have a higher average productivity from its labor to make the productivity gap effect sufficiently large; and (2) the entry cost faced by the midstream firm must be low enough. As long as these two conditions are satisfied, the productivity gap effect will be dominated by the entry cost gap effect.

3.3. Industry Level Division of the Gains in Global Supply Chains

In order to make our theoretical analysis generic to the industry level setting, we first set out the following definition regarding the one-to-one mapping between the country and each production stage involved in the chain. Such definitions allow us to shed light on the macro-economic development implications of the profitability-driven smile curve.

**Definition 1.** There is one-to-one correspondence between a set of countries \( c_i \in C_i \) and a set of stages \( s_i \in S_i \) in the global supply chain which is a function of: \( C_i \rightarrow S_i \) where \( i = 1, 2 \) and 3.

Bearing Definition 1 in mind, the aggregate level of industry profits obtained by each country in the chain can be computed as follows:

\[
\begin{align*}
\Pi_1 &= \sum_{i=1}^{n_1} \frac{n_i(q^*)}{q^*} = \sum_{i=1}^{n_1} \left( 1 - \lambda \right) w_i(q^*)^{\lambda - 1} \frac{F_i(q^*)}{q^*}, \\
\Pi_2 &= \sum_{j=1}^{n_2} \frac{n_j(q^*)}{q^*} = \sum_{j=1}^{n_2} \left( 1 - \lambda \right) w_j(q^*)^{\lambda - 1} \frac{F_j(q^*)}{q^*}, \\
\Pi_3 &= \sum_{k=1}^{n_3} \frac{n_k(q^*)}{q^*} = \sum_{k=1}^{n_3} \left( 1 - \lambda \right) w_k(q^*)^{\lambda - 1} \frac{F_k(q^*)}{q^*},
\end{align*}
\]

(18)

We first compare the division of the gains between country 1 specializing in the upstream stage in the chain and country 2 specializing in the midstream stage in the chain.

From (18), it may be derived that so long as a symmetrical market structure lies across the various production stages along the chain, the U-shaped profitability-driven smile curve at the industry level holds if and only if the following proposition is satisfied: \( ^{11} \)
Proposition 3. Given the symmetrical market structure across production stages along the chain, the average aggregate industry profitability of countries specializing in the upstream or downstream production stages is higher than that of their midstream counterparts; hence, the U-shaped country-level profitability-driven smile curve becomes valid if and only if the aggregate industry labor-productivity gap effect dominates the aggregate industry entry cost gap effect, namely:

\[ \left\{ (1 - \lambda) \left[ \sum_{i=1}^{n_1} \frac{w_i}{L_i} \frac{(q^*)^{1-1}}{n_i-1} - \sum_{j=1}^{n_2} \frac{w_j}{L_j} \frac{(q^*)^{1-1}}{n_2-1} \right] \right\} > \left\{ (1 - \lambda) \left[ \sum_{k=1}^{n_3} \frac{w_k}{L_k} \frac{(q^*)^{1-1}}{n_3-1} - \sum_{j=1}^{n_4} \frac{w_j}{L_j} \frac{(q^*)^{1-1}}{n_4-1} \right] \right\} \]

The proof of Proposition 3 is similar to that of Proposition 1.

Proposition 3 indicates that the gains from trade for those countries specializing in pre- and post-fabrication services (R&D and marketing) in the supply chains will be higher than that of their midstream assembly stage of the chains if and only if the aggregate industry productivity level of the latter is strictly dominated by the aggregate industry productivity level of the former. Second, the aggregate industry entry cost effect of countries specializing in midstream will have to be higher than that of their counterparts specializing in pre- and post-fabrication services. The country-level profitability-driven smile curve will hold if the two above conditions are satisfied.

The next question to ask is what conditions would precede the emergence of the inverted U-shaped profitability-driven smile curve. This leads to the last proposition in this paper:

Proposition 4. Given the symmetrical market structure across production stages along the chain, the average aggregate industry profitability of countries specializing in the upstream or downstream production stage is smaller than its midstream counterpart so that the inverted U-shaped country-level profitability-driven smile curve becomes valid if and only if the aggregate industry labor-productivity gap effect is dominated by the aggregate industry entry cost gap effect, namely:

\[ \left\{ (1 - \lambda) \left[ \sum_{i=1}^{n_1} \frac{w_i}{L_i} \frac{(q^*)^{1-1}}{n_i-1} - \sum_{j=1}^{n_2} \frac{w_j}{L_j} \frac{(q^*)^{1-1}}{n_2-1} \right] \right\} < \left\{ (1 - \lambda) \left[ \sum_{k=1}^{n_3} \frac{w_k}{L_k} \frac{(q^*)^{1-1}}{n_3-1} - \sum_{j=1}^{n_4} \frac{w_j}{L_j} \frac{(q^*)^{1-1}}{n_4-1} \right] \right\} \]
The proof of Proposition 4 is similar to that of Proposition 1.

Proposition 4 indicates that a developing country participating in the midstream stage of a global supply chain has higher aggregate industry profitability than that of the developed countries specializing in the pre- and post-fabrication production stages if and only if the two following conditions are satisfied. First, the aggregate industry productivity level of the developed countries must be strictly dominated by the aggregate industry productivity level of the developing countries. Second, the aggregate industry cost level of the developing countries in the midstream of the chains must be strictly lower than that of the developed countries at the two ends of the chains. These two conditions imply that the condition for the success of outsourcing industrialization for developing countries in the midstream stage of the chain is that these countries should have high aggregate industry productivity in addition to a low aggregate industry entry cost.

4. Empirical Evidence

In this section, we use industry-level data from the World-Input-Output Database (WIOD) to empirically test the existence of the U-shape smile curve and the propositions in section 3.

4.1. Data Source and Variables

Although there has never so far been a database for supply chains on the global level per se, obliging us to find a proxy, we can take advantage of industry-level WIOD data from 1995–2011. WIOD provides 25 key economic variables, such as output, capital, labor, etc. from 35 industries over 40 countries. The reasons for our use of WIOD data are that WIOD provides industry-level data that are comparable across 40 different countries and include trade flows for imports and exports in all the industries from these 40 countries. Second, in the empirical analysis we use a measure of upstreamness from Antràs and Chor (2018). The upstreamness index developed by these writers is based on the input-output table from WIOD from 1995 to 2011.

The first that we face is how to locate an industry in a supply chain. We opt for the measure of upstreamness developed by Antràs and Chor (2018), according to which the relative position of the 37 industries in WIOD is given by its relative usage in intermediate vs. final production, as retrieved from the input-output table constructed by WIOD. Furthermore, relative ranking allows us to apply a dummy variable in regression.

Before testing the propositions, we first testify whether or not there is a U-shape “smile curve” in our data. To test for the U-shape smile curve, we estimate the following regression using WIOD data:
\[
\left( \frac{\text{value added}}{\text{gross output}} \right) = \beta_0 + \beta_1 \text{Upstream} + \beta_2 \text{Upstream}^2 + \text{controls} + \epsilon \quad (19)
\]

The dependent variable is the value-added content of an industry-country; it is the value added in an industry divided by its gross output, as in Rungi and Del (2018). Variable Upstream is the measure of upstreamness sourced from Antràs and Chor (2018). Control variables include the log of capital intensity, log of labor productivity, and share of high-skilled labor compensation. Country, industry and year dummies are also included to control the fixed effects.

For all specifications in Table S1, the coefficient of \( \text{Upstream}^2 \) is significantly positive. It indicates that the smile curve in our data is U-shaped.

### 4.2. Empirical Analysis

This section seeks to verify the correctness of Proposition 3 and Proposition 4. We construct the associated variables: \( \text{labor productivity} \) is obtained by the total output of each industry divided by the number of employees. There are, however, no data for entry cost at the industry level. So we proxy an industry’s entry cost by its capital-labor ratio, which is the ratio of an industry’s real fixed capital stock to the number of employees. The intuition behind this is that the more capital-intensive industries normally incur a higher entry cost.

However, it is hard to directly compare the gaps between \( \text{labor productivity} \) and \( \text{entry cost} \) because they are measured differently. To address this issue, we rank all the industries in a given year by the measure of their upstreamness. For example, in the industry of mining and quarrying, Basic Metals and Fabricated Metal are the most upstream industries, while education, health and social work are the common downstream industries.

Based on the ranking of upstreamness, we further compare every industry with its adjacent downstream counterpart. The labor productivity gap in industry \( j \) in country \( i \) at year \( t \) is constructed as:

\[
\text{labor productivity gap}_{j,i,t} = \left( \frac{\text{labor productivity}_{j,i,t} - \text{labor productivity}_{j+1,i,t}}{\text{labor productivity}_{j,i,t}} \right)
\]

where \( j + 1 \) denotes industry \( j \)’s adjacent downstream industry.

Likewise, the entry cost gap in industry \( j \) in country \( i \) at year \( t \) is constructed as:

\[
\text{entry cost gap}_{j,i,t} = \left( \frac{\text{entry cost}_{j,i,t} - \text{entry cost}_{j+1,i,t}}{\text{entry cost}_{j,i,t}} \right)
\]

Finally, a dummy variable (\( \text{test} \)) is constructed to address the condition for our propositions: if industry \( j \)’s labor productivity gap is wider than its entry
cost gap, the dummy variable equals 1; otherwise, the dummy variable equals 0.

To test Proposition 3, we propose the following estimation equation:

$$Y_{j,i,t} = \beta_0 + \beta_1 \cdot Test_{j,i,t} + \beta_2 \cdot X_{j,i,t} + \epsilon_{j,i,t}$$  \hspace{1cm} (20)

where the dependent variables can be an industry’s profit or its upstreamness. The profits in industry $j$ in country $i$ in a year $t$ are constructed as follows:

$$\text{profit}_{j,i,t} = \text{exchange rate}_{i,t} \times \left( \frac{\text{gross output}_{j,i,t}}{\text{labour compensation}_{j,i,t} - \text{capital compensation}_{j,i,t}} \right)$$  \hspace{1cm} (21)

In the above model, $X$ represents the following control variables: (1) ‘capital-labor ratio’ ($\text{capital/labor}$); (2) ‘labor productivity’ ($\text{output/labor}$); (3) ‘share of high-skilled labor in total labor compensation’ ($\text{LABHS}$), and their interaction terms. In addition, we include industry, country and year dummies in all regressions to control for these fixed effects.

We use panel data regressions here to make better use of both time dimensional and cross-sectional data. Table S2 summarizes the descriptive statistics.

For upstream and midstream industries, if an industry’s $test$ equals 1, i.e., compared with its adjacent downstream industry, this industry faces a wider labor productivity gap than its entry cost gap. Similarly, the first inequality in Proposition 1 holds; in this case the industry earns a higher profit, and therefore this industry is more likely to be in an upstream than a midstream position. Therefore, for both dependent variables, profit and upstreamness, Proposition 1 entails a positive coefficient of the dummy variable $test$. Likewise, in order to test Proposition 2, we can look at the midstream and downstream industries. For the midstream and downstream industries, if an industry’s $test$ equals 0, i.e., compared to its adjacent downstream industry, this industry faces a smaller labor productivity gap than its entry cost gap. Therefore, this industry earns a high profit as well, and in this case this industry is more likely to be in a midstream than a downstream position. Therefore, for both dependent variables, profit and upstreamness, Proposition 1 and Proposition 2 entail a positive coefficient of the $test$.

In Table S3, we report the regression results using profit as the dependent variable.

In Table S4, we report the regression results using upstreamness as the dependent variable.

According to Tables S3 and S4, the coefficients before the dummy variable $test$ are all significantly positive. This indicates that if one industry and its adjacent counterpart have a labor productivity gap wider than their entry cost gap, this industry is more profitable than its adjacent counterpart.

Empirically, Proposition 3 is valid, which suggests that when the labor productivity gap dominates the entry cost gap, the smile curve is U-shaped.
The empirical result also implies that if the labor productivity gap is dominated by the entry cost gap, the smile curve is in an inverted U-shape and midstream industry may yield the highest level of profits.

5. Policy Implications

One of the most important policy implications deriving from the theoretical and empirical results of this paper is that we derive the key conditions in which developing countries could efficiently use the outsourcing opportunities in the midstream stage of the chains from rich nations so as to successfully industrialize themselves. We demonstrate in a theoretical model that the relevance of the profitability-driven smile curve lies in those aspects of the aggregate industry labor productivity and entry cost of the particular production stages that developing countries opt to specialize in when they enter the global supply chains. We argue that if developing countries involved in the global supply chain trade have a higher aggregate industry productivity level and a lower aggregate industry entry cost, then the aggregate industry profits that one country can obtain in the midstream stages of the chains will exceed those of the developed countries specializing in the pre- and post-fabrication services in the chains. This provides opportunities for developing countries to industrialize themselves through receiving outsourcing opportunities from developed countries. This process in what we have called outsourcing industrialization is the key to successful economic development in the four little dragon countries in East Asia, as well as mainland China. Several studies in the literature seem to support our argument. According to Hobday (1995), East Asian latecomer firms in the global electronics supply chain together provide one of the most typical examples of developing countries taking advantage of their participation in the manufacturing parts of production chains to undertake technological upgrading and subsequently gain competitiveness. Appelbaum and Christerson (1997) make a similar point: that outsourcing industrialization is key to the success of East Asian countries in their developmental strategy with particular reference to exporting-orientation. Another paper by Bernard and Ravenhill (1995) illustrates the relevance of participation in the manufacturing sectors of global production networks to an accelerated industrialization process in East Asian countries. The reason for us to emphasize the profitability-driven smile curve rather than value-added driven smile curve is mainly that outsourcing industrialization cannot be regarded as a rational strategy for developing countries to adopt if they follow the policy implications derived from the value-added smile curve. The value-added smile curve would indicate that developing countries will always be the losers in the supply chains if they specialize only in midstream manufacturing. This is because the value-added smile curve naturally assumes that the midstream
manufacturing stages of the supply chains have the lowest value-added, compared with the upstream R&D and downstream marketing stages. As a result, if developing countries engage in outsourcing activities in the midstream production stage, then they must occupy an inferior position to the rich nations at the two ends of the curve. The profitability-driven smile curve proposed in this paper allows researchers in the field to reexamine whether midstream countries in the chains can be competitive or not; in this regard, we found that in certain industry conditions (high aggregate industry productivity with low aggregate industry entry cost), countries in the middle do benefit from contributing to the manufacturing parts of the global supply chain trade.

6. Concluding Remarks

It becomes clear now that in terms of profitability distribution in a supply chain the choice of upstream/downstream/midstream is neither fixed nor universal. By constructing a hierarchy assignment model, our analysis indicates that an industrializing economy may enjoy higher returns by staying in the midstream of a supply chain as long as decision-makers and business leaders can target the particular production stages where high labor productivity and low entry cost obtain. In other words, the midstream position is not necessarily always the loser in the global supply chains. By employing data from the world input-output table, we found that the empirical results presented at the ends of the curve are broadly consistent with the theories proposed in the paper. Our research is likely to have far-reaching implications for the current debate on the industrial development of a nation through participating in the global supply chains.

Notes

1. The ‘smiling curve’ was created by the Taiwanese entrepreneur Stan Shih, the founder of ACER.
2. This concept was empirically tested by Ming, Meng and Wei (2015). They used time-series from the WIOD to examine the ‘smiling curve’, pinpointing the positions of industries in a supply chain by Lentief’s forward linkage and Leontief’s backward linkage. Their method provides a way of locating partners in a global supply chain.
3. Similar views have been expressed by Pomfret. (2014). Porter (1985)’s theory of the competitive advantage of nations, moreover, is the pioneering work illustrating the relevance of the effect of value chain activities on profitability sharing among the firms involved in the chains.
4. It is widely known that, in a production stage such as R&D or Marketing, firms have to spend a great deal on financing the R&D as well as on advertising. Furthermore, these non-fabrication services also employ high-skilled workers who normally command very high wages.
5. Although the paper by Baldwin and Evenett (2015) pointed out that the factor payment and profit margins are two parts of the value-added generated by each particular production stage of the value chain, they do not acknowledge that the inclusion of the factor payment cost in the value-added could largely misrepresent the policy implications of the value-added driven smile curve.

6. The results will also hold if $\alpha_i = 1$, implying a constant return to scale. The reason for making the increasing return to scale is that we assume that firms can sustain higher profitability by upgrading their technology. This is consistent with the prevailing endogenous growth model (Romer 1986, 1990).

7. This condition implies a fixed supply function at each stage. Stigler (1951) first recognized this condition when he studied the industry cycle.

8. The reason for stating the ex-post nature of the output in Assumption 1 is to ensure that the ex-ante output is still an endogenous variable given the firm optimization problem.

9. According to Sutton and Trefler (2016), the average product of labor is equivalent to the unit cost of production. Hence, in dimensional analysis, both the ‘average product of labor effect’ and the ‘entry cost effect’ can be measured by a monetary value per unit which is consistent with the left hand term measured by profit per unit.


11. The symmetrical market structure here would imply $n_1 = n_2 = n_3$ even though this assumption may not hold in practice, while it provides a benchmark for which one could generalize the firm-level division of the gains in the supply chains to the case of industry-level analysis.

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WIOD data www.wiod.org.