Profit Sharing, Industrial Upgrading, and Global Supply Chains: Theory and Evidence

XiaoJi Liu, Haiyue Liu, ShiYi Liu,
Jim H. Shen, and Chien-Chiang Lee

CID Research Fellow and Graduate Student
Working Paper No. 123
February 2020

Working Papers

Center for International Development
at Harvard University

Profit Sharing, Industrial Upgrading and Global Supply Chains: Theory and Evidence

XiaoJie Liu[1]

Haiyue Liu[2]

ShiYi Liu[3]

Jim.H. Shen[4]

Chien-Chiang Lee[5]

[1] Department of Managerial Economics and Decision Sciences, Northwestern University. Contact Email: xiaojieliu2024@u.northwestern.edu

[2] Business School, Sichuan University. Contact Email: seamoon@scu.edu.cn

[3] Business School, Sichuan University. Contact Email: liushiyi@stu.scu.edu.cn

[4] Center for International Development, Harvard University. Department of Economics, SOAS University of London. Contact email: huangnanjim@hotmail.co.uk

[5] Corresponding Author, School of Economics and Management, Nanchang University. Contact Email: cclee6101@gmail.com

Abstract

This paper constructed a simple model to illustrate the global supply chain profit sharing and industrial upgrading mechanism, from which it was found that the average profitability distribution in the different supply chain stages was determined by two main factors: (1) the average product of the labor in the firms at each production stage; and (2) the ratio of the output elasticity of capital to the output elasticity of labor in each stage. This paper also proposed a new industrial upgrading mechanism, the 'inter-supply chain upgrading', for supply chain firms. Rises in production complexity and increased factor intensity in each production stage were found to be the two essential conditions for the inter-supply chain upgrading. The empirical study results were found to be broadly consistent with the proposed theories.

Keywords: global supply chain; smile curve; profit sharing mechanism; upgrading mechanism; average product of labour; inter-supply chain upgrading; factor intensity.

JEL Classification Codes: F1, D2, D4.

1. Introduction

Globalization has led to a fragmentation in manufacturing production across national borders, with trade economists using varying terminologies such as "intra-product specialization" or "the unbundling of production " (Arndt, 1997, 1998; Baldwin and Gonzalez, 2012) to describe the new supply chain driven global division of labor trade patterns in which each country specializes in a particular stage of a good's production (Costinot et al., 2013).

As a result, trade in intermediate goods has gradually become a dominant global trade pattern as evidenced by the dramatic rise in the percentage share of intermediate products in world trade flows, which have been more than half of all non-fuel world exports since 2000. Consequently, global supply chain (GSC) issues with a particular reference to multinational corporations (MNCs) have been widely investigated in international economics and international business literature

This paper examined how profits are shared between the different firms involved in global supply chains from a 'smile curve' perspective, a focus that has been widely discussed in international business literature but rarely explored in economics literature. Management and international business research has examined how the Global Value Chain (GVC) value-added in each stage has been distributed, and developed a U-shaped distributional pattern hypothesis (Mudambi, 2007, 2008; Stan Shih, 1996; Ming et.al 2015).[6] The core theme of the 'smile curve' is that there is a U-shaped curve for the firms' value-added distribution across the three supply chain stages: R&D, assembly, and

[6] The concept of "smile curve "was firstly coined Taiwanese entrepreneur Stan Shin (1996) who is the founder of ACER in the 1990s.

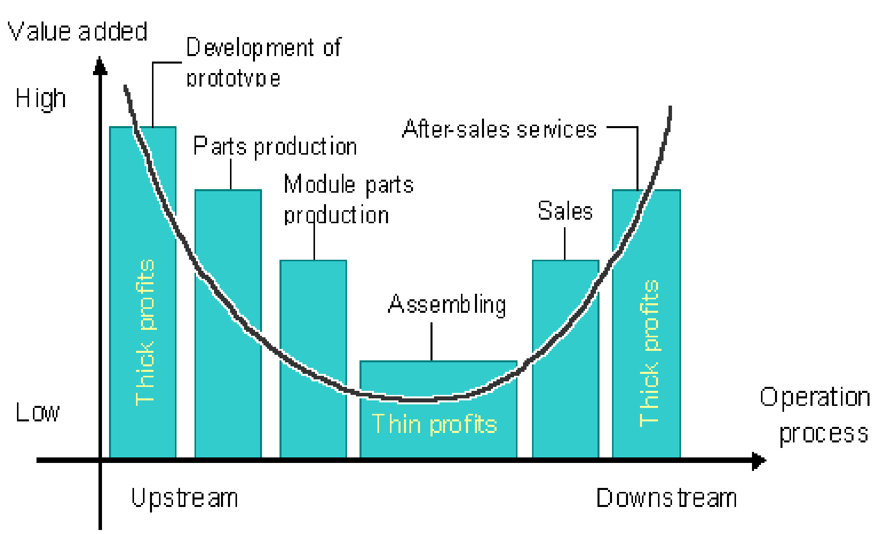
marketing. For example, in the semi-conductor global supply chain, most upstream production stages involves innovation and knowledge-intensive R&D activities, such as integrated circuit (IC) design, the midstream stage involves low-value added activities, such as wafer production, precision testing and assembly, and the downstream chain stage activities involve marketing and post-sale services. Therefore, the U-shaped pattern hypothesis was mainly because the upstream and downstream firms have higher-value added than the middle stage wafer fabrication, which is subject to manufacturing subcontracts.

The main problem with the smile curve hypothesis is that there have been no theoretical analyses that have corroborated the assumptions that the firms that provide the higher supply chain value-added are also those that are more profitable. As it is generally believed that value-added and profitability are two different concepts that cannot be equated, in this paper, the profit-sharing patterns in global supply chains are investigated to determine whether high-value added supply chain firms also have higher profit levels. There have seen some attempts to empirically test the U-shaped "smile curve"[7] hypothesis using the high-tech industry as a case study. For example, Shin et al. (2012) found that the leading firms and component suppliers in the upper stages had much higher gross and net profit margins than the manufacturing contractors in the middle production stage, and concluded that: the smile curve could be verified only if the value added was defined as the gross margins; that the cost of sustaining a position on either

[7] This concept was recently empirically tested by Ming.et.al (2015). They adopted time-series data from the WIOD with explicit consideration of both the benefits and the position of the participating countries and industries in the global supply chain to examine the hypothesis of "smile curve". Although this paper was the first paper in the field that used rigorous econometric tools to test the U-shaped hypothesis of smile curve, they did not come up with a theoretical framework.

end of the curve (upstream or downstream) could be too high to make the returns on investment higher than the middle of the curve because of the long investment gestation in high-tech industries; and that it was ambiguous whether specialist firms at the two ends of the curve were more profitable than those in the middle.

Therefore, what sets this paper's analyses apart from this other work is that first, it investigates the extent to which the smile curve moves in the same direction after "profitability" and value added are incorporated into the model and second, this paper further explores the effect on supply chain firm profitability of a rise in technological capabilities; that is, this paper examined the industrial upgrading mechanism through which firms could obtain higher profitability. Figure 1 illustrates the smile curve operations.



Sources: Aoki Masahiko and Ando Haruhiko (2002)

Figure 1. Smile Curve

In contrast to previous research on industrial upgrading strategies for supply chain firms, as this paper does not consider an inter-stage supply chain upgrading mechanism, the curve does not flatten out to the same extent, and the exclusion of the inter-stage upgrading ensures that the focus is only on an upward parallel shift for the whole global supply chain, which means that the firms remain within the same production stage, but a higher profitability level is captured, as shown in Figure 2.

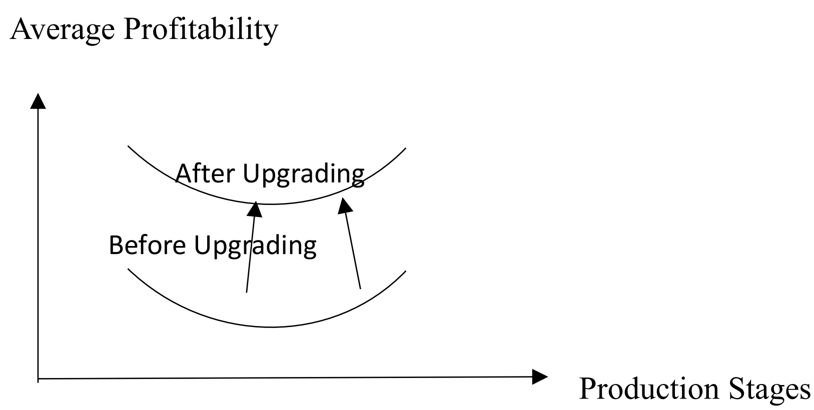


Figure 2. Supply Chain Upgrading Mechanism

Therefore, the above diagram contributes to a new understanding of the supply chain upgrading mechanism as it demonstrates that the upward shift in the whole supply chain results in a positive spillover for all firms in the low-profitability stages, which is called *inter-supply chain upgrading* in this paper. In the proposed model in the following section, it is shown that with increased production complexity and higher factor intensity in each stage in the chain, the less profitable firms in the middle of the smile curve learn elements such as technology advancement, branding and marketing management from the more profitable firms, which means that all firms in all production and distribution stages are more profitable than before.

The remainder of this paper is organized as follows. Section 2 reviews the pertinent literature, Section 3 gives the model solution, section 4 is our empirical analysis, and section 5 gives the concluding remarks.

2. Literature review

2.1 Past studies on profit sharing mechanisms

2.1.1 Global supply chain

As early as 1994, Gereffi and Korzeniewicz (1994) suggested that countries specializing in different supply chain stages had different production control rights and therefore there were role inequalities across the supply chain stages. Consequently, the countries located at the dominant stages had higher production control rights and higher profits. Gereffi and Kaplinsky (2001) then investigated an upgrading strategy for non-lead firms from developing countries participating in the supply chain, from which it was found that to gain greater profit, the firms specializing in the lowest value added chain stages could upgrade within the same stage or expand their supply chain functions. Kaplinsky (2004) used four chain case studies: fresh fruit and vegetables, canned deciduous fruit, footwear, and automobile components: to examine the value chain contributions, and found that there were three factors influencing the global value chain benefit distribution mechanism: (1) barriers to entry and rents (2) governance, and (3) systemic efficiency. Then, using a value chain analysis framework based on these three factors, Kaplinsky (2004) reviewed the unequal distribution gains and characterized the key global value chain concepts.

2.1.2 Market structure theories

Industrial organization theories have also been used to examine the unevenly distributed gains obtained by different countries in the supply chain from a dynamic market structure perspective. Pioneering work in this area was presented by Morris and Hay (1991), who established the "ladder pricing model" to analyze two production stages: one production stage consisting of m upstream firms and the other consisting of n downstream firms producing intermediate inputs and selling the final products to the market. Within this model, it was presumed that the firms producing the same products or the intermediate inputs were homogenous, there was no production stage collusion, and each firm equally shared the market. The ladder pricing model explained how uneven firm benefit distribution was contingent upon the market structure in each production stage, which was related to the number of firms in each production stage in the model.

Ju and Su (2013) developed a global supply chain model to study how profits were shared between the intermediate input suppliers and the final goods producers, from which they concluded that the differences in upstream and downstream stage market structures determined the profitability differences in the different firms along the global supply chain. Using Melitz and Ottaviano's (2008) heterogeneous firm framework, it was assumed that the downstream market firms operated within a monopolistic competition environment, and the upstream market operated within an oligopolistic (Cournot) competition environment, and because of the obvious exogenous market structure settings, they also illustrated the effects that market structure dynamics could have on the profit-sharing patterns in a vertical production structure.

Similarly, using Chinese industry level input-output data, Ju and Yu (2015) also found that entry cost increases in the upstream market and final good market segmentation increased (decreased) the market power of the intermediate input (final good) producers, which in turn increased (decreased) their profitability, and that the prices determined from demand increases for the final good had effects on the profit sharing system along the whole global supply chain.

Therefore, to some degree, this paper is in line with previous research in this area that examined profit-sharing in global supply chains, except that this paper assumes that as the market structure in each stage is monopolistic; that is, there is only one monopolistic firm involved in each stage; there are no sunk costs for entry or exit in any stage, and all firms including incumbents and new entrants in each production stage have access to the same level of technology in each particular production stage.

2.2 Upgrading mechanisms

The global supply chain upgrading mechanism discussed in this paper is mostly based on Costinot et al. (2013) and Humphrey and Schmitz (2002). This paper also tried to capture the impacts that local technology had on the global supply chain upgrading processes. Costinot's et al. (2013) claimed that there were two local technological changes; one associated with a labor-augmenting technical progress, and the other related to a decrease in a country's failure rate, which was called "routinization". In this paper, however, inter-supply chain upgrading was used to describe these two technological advancement forms, and it is proposed that inter-supply chain upgrading is possible if there is an increase in a firm's factor intensity or there is an advancement in the production complexity at a particular stage.

The inter-supply chain upgrading definitions in management research have been generally similar to the upgrading mechanism concepts discussed in Humphrey and Schmitz (2002), who divided the upgrading mechanism into four categories: (1) firms that reorganize the production system or introduce superior technology to more efficiently transform the inputs into outputs; (2) product upgrading - firms that upgrade by moving into more sophisticated product lines that have increased unit values; (3) functional upgrading where firms acquire new chain functions, such as design or marketing; and (4) inter-sector upgrading- firms that apply the competencies acquired from a particular chain function (e.g competence in producing particular inputs, or in export marketing) to a new sector (Humphrey &Schmitz, 2002). As the first two upgrading patterns are more compatible with the inter-supply chain upgrading discussed in this paper, only these two are considered here.

3. Model

3.1 Profit Sharing mechanisms in global supply chains

The model developed in this paper is in line with the hierarchy assignment model techniques used in Lucas (1982), Kremer (1993), and Garicano & Rossi-Hansberg (2004, 2006) except that this technique is integrated into the global value chain sequential production framework, as also attempted by Costinot et al. (2013) and Shen et al.(2019). The difference between the model in this paper and these previous models is that capital input is also incorporated into the sequential production process.

Suppose that each representative firm at a particular stage s_i seeks to maximize their own profit:

$$\pi(s_i, \mathrm{q}) = \mathrm{p}(s_i)\mathrm{q}(s_i) - \mathrm{w}(s_i)\mathrm{L}(s_i, q) - \mathrm{r}(s_i)\mathrm{K}(s_i, \mathrm{q})$$

(1)

where π is the profit function, L indicates the labor employed by this firm and is the function of the output and different production stages, K is the amount of capital deployed by this firm, which is a function of the output and different production stages, and q is the ex-ante output, which is the chosen variable. The reason the output here is ex-ante is because it is assumed that as each firm in the sequential stages engages in the quantity-fixing contract specified by most upstream supply chain firms, the ex-post output is fixed (Rey and Verge, 2004; Verge, 2001). The rationale for the adoption of the quantity-fixing contract is that in classical I-O literature, a vertical restraint mechanism needs to be used to remove the potential double marginalization problems when studying firm-level profit-distribution under a vertical production structure. p(s_i) is the price for each unit of output in the *i* th stage, w is the wage rate, and r is the interest rate.

Therefore, given this information, the following assumptions underly this research.

Assumption 1. The ex-post output under the fixed quantity contract is:

q$(s_i) = q^*$ where $1 \le i \le n$

Taking the derivative of q on both sides,

$$\frac{\partial \pi(s_i,q)}{\partial q} = p(s_i) - w(s_i)\frac{\partial L(s_i,q)}{\partial q} - r(s_i)\frac{\partial K(s_i,q)}{\partial q} = 0$$

(2)

Then

$$\mathrm{p}(s_i) = w(s_i)\frac{\partial L(s_i,q)}{\partial q} + r\frac{\partial K(s_i,q)}{\partial q}$$

(3)

In line with Dalamzzo (2007) and Kremer (1993), it was assumed that the labor demand function for each firm in a particular stage was expressed as the following exponential function:

$$\mathrm{L}(s_i,\mathrm{q}) = [\mathrm{q}(s_i)]^{\lambda} l(s_i)$$

(4)

where $\lambda(s_i)$ is the production stage complexity. Here $0< \lambda(s_i) < 1$, and the higher $\lambda(s_i)$ is, the lower the level of complexity in each production stage as a higher value indicates a higher need for more labor and a greater labor-intensiveness, which normally indicates a lower production complexity compared with more capital-intensive firms. $l(s_i)$ is the inverse value for the average product of the labor at a particular stage in the chain.

Each firm at each stage in the value chain adopts Cobb-Douglas production technology:

$$\mathrm{q}(s_i) = K(s_i)^{\alpha(s_i)} L(s_i)^{\beta(s_i)}$$

(5)

Plugging (4) into (5), the capital demand function in each stage is obtained as follows:

$$\mathrm{K}(s_i,\mathrm{q}) = q^{\frac{1-\beta(s_i)\lambda(s_i)}{\alpha(s_i)}} l^{-\frac{\beta(s_i)}{\alpha(s_i)}}(s_i)$$

(6)

Plugging (4) and (6) into (3)， the price charged by a representative firm at a stage is obtained as follows:

$$\mathrm{p}(s_i) = \lambda(s_i)\mathrm{q}^{\lambda-1} w(s_i) l(s_i) + \frac{r(1-\beta(s_i)\lambda)}{\alpha(s_i)} q^{\frac{\beta(s_i)(1-\lambda)}{\alpha(s_i)}} l^{-\frac{\beta(s_i)}{\alpha(s_i)}}(s_i)$$

(7)

Based on the quantity-fixing contract assumption 1, the ex-post negotiated price between each sequential firm along the chain is as follows:

$$\mathrm{p}(s_i) = \lambda(s_i)\mathrm{q}^{*\lambda(s_i)-1} w(s_i) l(s_i) + \frac{r(s_i)(1-\beta(s_i)\lambda(s_i))}{\alpha(s_i)} q^{*\frac{\beta(s_i)(1-\lambda)}{\alpha(s_i)}} l^{-\frac{\beta(s_i)}{\alpha(s_i)}}(s_i)$$

(8)

Now dividing both sides of (1) with the fixed quantity q^*, the average profitability for a representative firm at a stage in the chain is obtained:

$$\frac{\pi(s_i,q)}{q^*} = p(s_i) - \frac{w(s_i)L(s_i)}{q^*} - \frac{r(s_i)K(s_i,q)}{q^*}$$

(9)

Plugging (8) into (9), the average profitability of a representative firm under the fixed quantity contract at a stage in the chain is expressed as follows:

$$\frac{\pi(s_i,q^*)}{q^*} = \frac{r(s_i)\beta(s_i)(1-\lambda s_i))}{\alpha} l^{-\frac{\beta(s_i)}{\alpha(s_i)}}(s_i) q^{*\frac{\beta(s_i)(1-\lambda)}{\alpha(s_i)}} - (1-\lambda(s_i))\frac{w(s_i)L(s_i,q^*)}{q^*}$$

(10)

(10) can be rewritten as follows:

$$\frac{\pi(s_i,q^*)}{q^*} = \underbrace{\frac{r(s_i)\beta(s_i)(1-\lambda(s_i))}{\alpha(s_i)}[\frac{q^{*1-\lambda}}{l(s_i)}]^{\frac{\beta(s_i)}{\alpha(s_i)}}}_{technological\ gains} - \underbrace{(1-\lambda(s_i))\frac{w(s_i)L(s_i,q^*)}{q^*}}_{labour\ cost\ gains}$$

(11)

Therefore, in equation (11), the average profitability at each representative firm in each stage is made up of two parts: technological advancement, which is related to the average product of labor and production complexity, and labor costs. To ensure model tractability, an additional assumption is made that the labor cost gains are the same for all firms along the global value chain. Although this assumption deviates from reality, as the main purpose of this paper was to examine the effect different technological capabilities had on the profitability of each firm in each stage in the global supply chain, without making this additional assumption, it would be more difficult to compare the average profitability across the different firms in the chains as these two types of gains may interact or even sometimes counteract each other, making the model unnecessarily complex. Therefore, we make the second assumption in this paper:

Assumption 2. $(1-\lambda(s_i))\frac{w(s_i)L(s_i,q^*)}{q^*}$=C,

From Assumption 2, it is known that equation (11) can be rewritten as follows:

$$\frac{\pi(s_i,q^*)}{q^*}=\frac{r(s_i)\beta(s_i)(1-\lambda(s_i))}{\alpha(s_i)}[\frac{q^*}{L(s_i,q^*)}]^{\frac{\beta(s_i)}{\alpha(s_i)}}-C$$

(12)

From (12), the following proposition in this paper is developed:

Proposition 1: *The smile curve hypothesis only holds if and only if the average product of labor is higher than* $max\{\left[\frac{\beta(s_2)\alpha(s_1)}{\beta(s_1)\alpha(s_2)}\right]^{\frac{\alpha(s_1)}{\beta(s_1)}}\left[\frac{q^*}{L(s_2,q^*)}\right]^{\frac{\beta(s_2)\alpha(s_1)}{\beta(s_1)\alpha(s_2)}},\ 1\}$, *at which time the average profit in the high value-added stages is larger than in the low value-added stages, where* s_1 *is the high value-added stage and* s_2 *is the low value added stage.*

Proof for proposition 1:

Consistent with smile curve literature, the production stages were classified into high value added stages and low value added stages, which was decided from the boundary values for the average product of the labor; therefore, a boundary value of 1 was decided on, where the high value-added stages $\frac{q^*}{L(s_i,q^*)}\geq 1$ and the low value-added stages $\frac{q^*}{L(s_i,q^*)}<1$. Let the high value-added stage be s_1, and its corresponding labor and capital elasticity of output be $\alpha(s_1)$ and $\beta(s_1)$. Let the low value-added stage be s_2, and its corresponding labor and capital elasticity of output be $\alpha(s_2)$and $\beta(s_2)$.

It is known that in the high value-added stages, $\frac{\beta(s_1)}{\alpha(s_1)}<\frac{\beta(s_2)}{\alpha(s_2)}$.

Therefore, it could also be derived that $[\frac{q^*}{L(s_1,q^*)}]^{\frac{\beta(s_1)}{\alpha(s_1)}}\geq[\frac{q^*}{L(s_2,q^*)}]^{\frac{\beta(s_2)}{\alpha(s_2)}}$

The above are crucial in understanding the profit-sharing mechanism along the chain.

First, the average product of labor determines the stage that has the higher average profit, and second, $\frac{\beta}{\alpha}$ also determines which stage has the higher average profit. Therefore, based on this, the average profit in the high value-added stages is equal to the the average profit in the low value-added stages when

$$\frac{\pi(s_1,q^*)}{q^*} > \frac{\pi(s_2,q^*)}{q^*}$$

(13)

putting (12) into (13)，

$$\frac{r\beta(s_1)(1-\lambda)}{\alpha(s_1)}\left[\frac{q^*}{L(s_1,q^*)}\right]^{\frac{\beta(s_1)}{\alpha(s_1)}} > \frac{r\beta(s_2)(1-\lambda)}{\alpha(s_2)}\left[\frac{q^*}{L(s_2,q^*)}\right]^{\frac{\beta(s_2)}{\alpha(s_2)}}$$

(14)

$$\frac{q^*}{L(s_1,q^*)} > \left[\frac{\beta(s_2)\alpha(s_1)}{\beta(s_1)\alpha(s_2)}\right]^{\frac{\alpha(s_1)}{\beta(s_1)}}\left[\frac{q^*}{L(s_2,q^*)}\right]^{\frac{\beta(s_2)\alpha(s_1)}{\beta(s_1)\alpha(s_2)}}$$

(15)

From (15), it is known that when $\frac{q^*}{L(s_1,q^*)} \geq \max\{\left[\frac{\beta(s_2)\alpha(s_1)}{\beta(s_1)\alpha(s_2)}\right]^{\frac{\alpha(s_1)}{\beta(s_1)}}\left[\frac{q^*}{L(s_2,q^*)}\right]^{\frac{\beta(s_2)\alpha(s_1)}{\beta(s_1)\alpha(s_2)}}, 1\}$, the average profit in the high value-added stages is higher than the average profit in the low value-added stages.

Proof Complete.

The primary intuition behind proposition 1 is that equation (15) indicates that the profitability distribution between the high value-added and low value-added firms is contingent upon two factors: the average product of labor in each stage and the ratio of the output elasticity of capital to the output elasticity of labor in each stage

3.2 Upgrading mechanism for firms along the global supply chain

From the average profit function under the fixing quantity contracts indicated in equation (12), a comparative static analysis could be conducted to derive the following two propositions for the inter-supply chain upgrading mechanism

Proposition 2: *An increase in the production complexity in each production stage leads to an increased average profitability for each firm in each production stage.*

Proof for Proposition 2:

$$\frac{\partial \frac{\pi(s_i,q^*)}{q^*}}{\partial \lambda(s_i)} = -\frac{r(s_i)\beta(s_i)}{\alpha(s_i)}\left[\frac{q^*}{L(s_i,q^*)}\right]^{\frac{\beta(s_i)}{\alpha(s_i)}} < 0 \qquad (16)$$

Proof Complete.

The intuition behind proposition 2 is that as $\lambda(s_i)$ represents the production complexity at each production stage in the chain, when λ is smaller, the production complexity is higher. It could be derived from $L(s_i, q) = q^{\lambda(s_i)} l(s_i)$ that when $\lambda(s_i)$ is smaller, less labor is demanded in each stage , which implies that the average product of labor $\frac{q}{L(s_i,q)}$ is higher, which in turn would increase the average profit in each stage in the chain.

Proposition 3: *The higher the factor intensity* $\frac{K(s_i,q)}{L(s_i,q)}$ *at stage* s_i *, the higher the average profit at production stage* s_i.

Proof for Proposition 3:

From $L(s_i, q) = q^{\lambda(s_i)} l(s_i)$ and $K(s_i, q) = q^{\frac{1-\beta(s_i)\lambda(s_i)}{\alpha(s_i)}} l^{-\frac{\beta(s_i)}{\alpha(s_i)}}(s_i)$, it could be obtained that

$$\frac{K(s_i,q^*)}{L(s_i,q^*)} = \left[\frac{q^*}{L(s_i,q)}\right]^{\frac{1}{\alpha(s_i)}}$$

(17)

The average profit function under the quantity-fixing contract can then be re-expressed as follows:

$$\frac{\pi(s_i,q^*)}{q^*} = \frac{r(s_i)\beta(s_i)(1-\lambda(s_i))}{\alpha(s_i)}[\frac{\mathrm{K}(\mathrm{s_i},\mathrm{q}^*)}{\mathrm{L}(\mathrm{s_i},\mathrm{q}^*)}]^{\beta(s_i)} - C$$

(18)

From (18),

$$\frac{\partial\frac{\pi(s_i,q^*)}{q^*}}{\partial\frac{\mathrm{K}(\mathrm{s_i},\mathrm{q}^*)}{\mathrm{L}(\mathrm{s_i},\mathrm{q}^*)}} = \frac{r(s_i)\beta(s_i)^2(1-\lambda(s_i))}{\alpha(s_i)}[\frac{\mathrm{K}(\mathrm{s_i},\mathrm{q}^*)}{\mathrm{L}(\mathrm{s_i},\mathrm{q}^*)}]^{\beta(s_i)-1} > 0$$

(19)

Proof Complete.

The intuition behind proposition 3 is that an increase in the factor intensity ratio $\frac{K}{L}$ leads to a higher average product of labor, which in turn increases the average profit in production stage s_i. Therefore, the U-shaped form for a particular global supply chain illustrates that the relationship between average profit and a particular production stage depends on the average product of labor in each production stage and the ratio of output capital elasticity to output labor elasticity in each stage. However, it must be remembered that for these theoretical results to hold, it must be assumed that there are no sunk costs for entrants to enter any stage in the chain, an assumption that was aligned with Shin et al. (2012), in which the correctness of the smile curve hypothesis became insignificant if the costs of sustaining the position at the two ends of the curve was considered.

Being embedded into a particular global supply chain stage provides opportunities for industrial upgrading for developing countries (Gereffi, 1999; Ernst, 2002; Schmizt and Humphrey, 2001; 2002,) as the firms gain tacit or explicit technological and management knowledge and additional resources, which would enable them to industrially upgrade and gain greater income. As corroborated in propositions 2 and 3, gaining greater income from inter-supply chain upgrading depends on production complexity and the factor intensities at a particular stage. Proposition 2 is also consistent with Costinot et al. (2013) in which technological change was defined as a rise in production complexity, and one of the implications of proposition 3 is that a dynamic change from being labor-intensive to being capital intensive in the comparative factor endowment advantage for a country (firm) at a particular stage was found to play an important role in the supply chain upgrading process. This theoretical result is compatible with the recent debate in development economics in which Lin (2012) discussed the importance of dynamic changes in comparative factor endowment advantages when determining the efficiency of industrial firms from developing countries.

4. Empirical Evidence

4.1 Data sources and variable descriptions

The main country-industry data source was the World Input-Output Database (WIOD) , the Input-output tables (WIOT) tables in which track current prices from 2000 to 2014, and cover 42 countries (17 developed countries and 25 developing) and 68 industries, with the rest of the countries regarded as a model for the rest of the world (RoW). The data for the 68 industries were classified based on the International Standard Industrial Classification revision 4 (ISIC Rev. 4), with the socio-economic accounts providing industry-level data for employment, capital stock, gross output and value added at current and constant prices. The data for the control variables, which consider the heterogeneous country characteristics, were extracted from the World Bank database. The detailed information on the variables and sources are listed in Table 1, and Table 2 gives the descriptive statistics.

Table 1. Variable Definitions and Data Sources

Variables	Definition	Measure	Data Sources
Explained variable			
PRO	Profit	The difference between value added and total capital compensation and labor compensation.	World Input-Output Database
Explanatory variables			
LP	Labor productivity	The ratio of gross output to employees in each industry. (takes the logarithm)	World Input-Output Database; Authors' calculation
CI	Capital intensity	The ratio of capital stock to employees in each industry. (takes the logarithm)	
TFP	Production complexity	Total factor productivity calculated using the LP method.	
Control variables			
Infra	Infrastructure	Overall country infrastructure construction level, using fixed telephone subscriptions (per 100 people). (takes the logarithm)	World Bank
Tech	Technological development	High-tech exports as a percentage of manufactured exports. (takes the logarithm)	
Popu	Population	All residents regardless of legal status or citizenship in a country. The values shown are midyear estimates. (takes the logarithm)	
GDPg	GDP growth	GDP growth rate.	
Open	Trade freedom	Exports of goods and services as a percentage of GDP. (takes the logarithm)	
FDI	Foreign direct investment	Net inflows of foreign investors (new investment inflows minus withdrawals) as a percentage of GDP. (takes the logarithm)	
Subsample criteria			
Economies	Economies	High income (OECD) group are developed countries; the medium to upper income group (UMC), medium to lower income group (LMC) and the low-income group (LIC) are developing countries.	World Bank
HC	Human capital	Percentage of working age population with an advanced level of education that are in the labor force.	

Table 2. Summary Statistics

Variables	Observation	Mean	Std. dev.	Min	Max
PRO	31,636	0.0346748	0.4922396	1.00E-11	46
LP	32,540	5.905857	2.13787	2.538653	13.08889
CI	32,091	5.685075	2.375388	2.082743	13.48473
TFP	32,091	4.51531	1.479537	1.427988	8.829166
Infra	35,280	3.547875	0.598727	0.735626	4.314052
Tech	35,280	2.508725	0.69588	0.388009	4.271072
Popu	35,280	16.69455	1.873323	12.87413	21.03389
GDPg	35,280	2.795517	3.614614	-14.8142	14.23139
Open	35,280	3.673969	0.589291	2.201999	5.359446
FDI	33,208	1.150786	1.347619	-6.52287	6.113053
Economies	31,920	0.657895	0.474422	0	1
HC	30,464	79.99955	4.09527	62.1768	89.9739

4.2 Profit-sharing mechanism test

The sample data used in this study were strongly balanced panel data, with the cross section being p (p=c×j, c∈{1,2,3,…}, i∈{1,2,3,…}, where c was country and j was industry, and the time series was from 2000 to 2014. Because of the heterogeneity of the basic country-level conditions, subsamples were established to conduct the regression analysis on the developed and developing countries. The human capital level was taken as the criterion and the sample countries divided into three sub-samples based on the quantile.

Equation (20) and equation (21) were applied to explore the effects of industrial labor productivity and capital intensity on the profits, the specific designs for which were;

$$PRO_{it} = \alpha + \beta LP_{it} + \sum_m \gamma_m Country_{it} + \theta_i + \theta_t + \varepsilon_{it} \qquad (20)$$

$$PRO_{it} = \alpha + \beta CI_{it} + \sum_m \gamma_m Country_{it} + \theta_i + \theta_t + \varepsilon_{it} \qquad (21)$$

where the explained variable PRO_{it} was the logarithm for the difference between the value added and total capital compensation and labor compensation in industry *i* in country *c* in year *t* , which was the proxy for the profit gained. The explanatory variable was either the logarithm for labor productivity or the logarithm for capital intensity. $Country_{ct}$ was a set of control variables at the country level: infrastructure, scientific and technological level, population, GDP growth, openness and foreign direct investment: θ_i was the industry fixed effects to control for individual-invariant characteristics, θ_t indicated the time fixed effect that controlled the time-invariant characteristics, and ε_{it} was the error term. The OLS method was used for the regression and a robust standard error added to control heteroscedasticity.

Figures 3 and 4 are the scatter diagrams and fitting curves for the labor productivity (*LP*) and capital intensity (*CI*) related to the profit (*PRO*), which indicates that there were obvious positive relationships for all country-industry pairs.

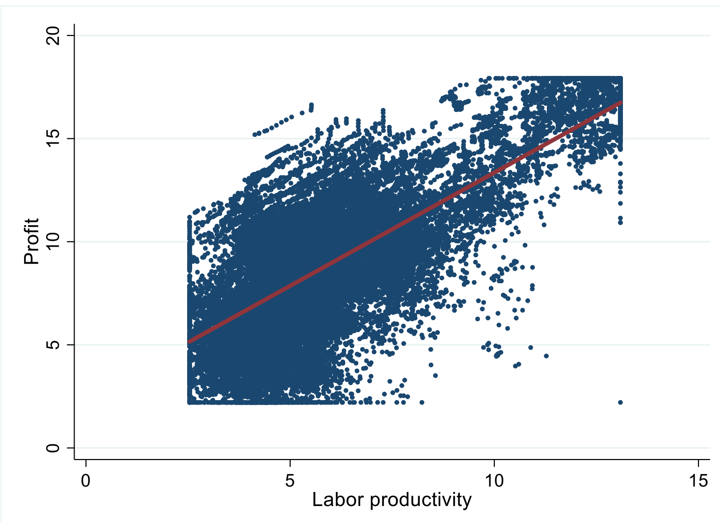


Figure 3. Labor productivity and profit

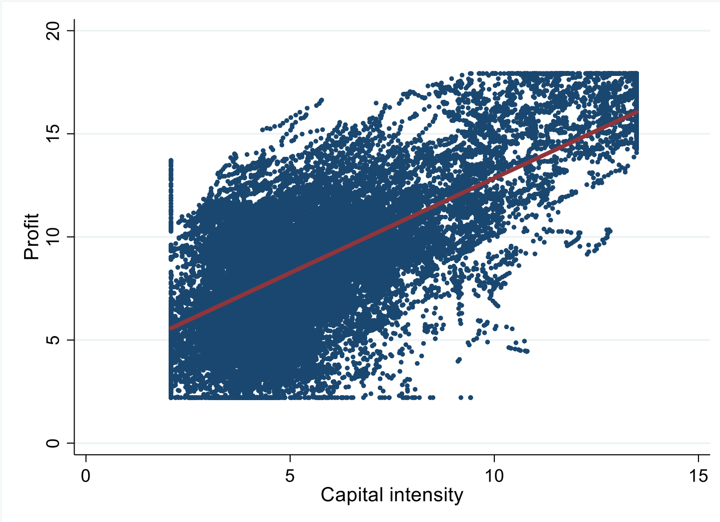


Figure 4. Capital intensity and profit

4.2.1 Full sample results

Table 3 shows the results for models (20) and (21). In columns (1) and (4), the fixed effects were not considered in the regression; in columns (2) and (5), only the time fixed effects were controlled for; and in columns (3) and (6), two-way fixed effects (both time and individual) were added. Across all specifications, the coefficients for *LP* and *CI* were significantly positive, which indicated that the higher the labor productivity and capital intensity of an industry, the higher the profit. Therefore, propositions 1 and 2 were verified.

Table 3. Labor productivity, capital intensity and profit

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	*PRO*					
LP	0.0421***	0.0424***	0.0480***			
	(0.00508)	(0.00516)	(0.00580)			
CI				0.0311***	0.0311***	0.0390***
				(0.00352)	(0.00354)	(0.00447)
Infra	-0.0453***	-0.0393***	-0.0349***	-0.0434***	-0.0374***	-0.0321***
	(0.00717)	(0.00747)	(0.00728)	(0.00729)	(0.00761)	(0.00742)
Tech	-0.0256***	-0.0254***	-0.0316***	-0.0146***	-0.0138***	-0.0217***
	(0.00597)	(0.00577)	(0.00640)	(0.00471)	(0.00441)	(0.00521)
Popu	-0.00229**	-0.00347***	-0.00298***	0.00537***	0.00410***	0.00176**
	(0.00105)	(0.00111)	(0.000812)	(0.00148)	(0.00104)	(0.000892)
GDPg	0.00299***	0.00577***	0.00557***	0.00334***	0.00622***	0.00599***

	(0.000397)	(0.00142)	(0.00141)	(0.000431)	(0.00147)	(0.00145)
Open	-0.0145***	-0.0227***	-0.000337***	-0.000196	-0.00837	-0.000257***
	(0.00413)	(0.00756)	(0.000106)	(0.00293)	(0.00587)	(9.46e-05)
FDI	0.00532**	0.00796**	0.00920**	0.00216	0.00429	0.00706**
	(0.00247)	(0.00355)	(0.00363)	(0.00208)	(0.00308)	(0.00335)
Constant	0.0896**	0.0944**	0.0519	-0.0493	-0.0466	-0.0372
	(0.0357)	(0.0383)	(0.0529)	(0.0347)	(0.0323)	(0.0560)
Year FE	NO	YES	YES	NO	YES	YES
Industry FE	NO	NO	YES	NO	NO	YES
Observations	29,053	29,053	29,053	28,915	28,915	28,915
R-squared	0.034	0.035	0.044	0.028	0.029	0.039

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

4.2.2 Subsample results

Tables 4 and 5 give the results when the samples were classified into different economic and human capital levels. Across all subsamples and specifications, both *LP* and *CI* showed significant positive correlations with profit, and were not affected by the country-level economic heterogeneity or the human capital discrepancies

Table 4. Labor productivity, capital intensity and profit (developed vs developing)

	(1)	(2)	(3)	(4)
	PRO			
Variable	*developed*	*developing*	*developed*	*developing*
LP	0.0142***	0.129***		
	(0.00116)	(0.0178)		
CI			0.0120***	0.104***
			(0.000968)	(0.0134)
Infra	0.0183***	-0.0457**	0.0176***	-0.0210
	(0.00384)	(0.0184)	(0.00387)	(0.0194)
Tech	0.000202	-0.0912***	0.00223**	-0.0617***
	(0.000888)	(0.0149)	(0.000902)	(0.0105)
Popu	0.000594	-0.0878***	0.00166***	-0.0653***
	(0.000567)	(0.0117)	(0.000599)	(0.00809)
GDPg	0.000250	0.00883***	0.000784	0.00868***
	(0.000529)	(0.00305)	(0.000556)	(0.00308)
Open	6.88e-05***	-0.00977***	9.09e-05***	-0.00866***
	(2.39e-05)	(0.00159)	(2.46e-05)	(0.00136)
FDI	-0.00236***	0.0121	-0.00307***	0.00443
	(0.000672)	(0.00930)	(0.000708)	(0.00868)
Constant	-0.145***	1.677***	-0.161***	1.197***
	(0.0234)	(0.251)	(0.0243)	(0.203)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

Observations	17,729	8,997	17,642	8,946
R-squared	0.076	0.087	0.070	0.074

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Labor productivity, capital intensity and profit (different levels of human capital)

Variable	(1) *PRO* *High-HC*	(2) *Mid-HC*	(3) *Low-HC*	(4) *High-HC*	(5) *Mid-HC*	(6) *Low-HC*
LP	0.0949***	0.0361***	0.00165**			
	(0.0156)	(0.00905)	(0.000712)			
CI				0.0844***	0.0262***	0.00125**
				(0.0127)	(0.00660)	(0.000590)
Infra	-0.0686***	-0.0902***	0.00354*	-0.0743***	-0.0963***	0.00336*
	(0.0254)	(0.0214)	(0.00197)	(0.0257)	(0.0228)	(0.00197)
Tech	-0.0956***	0.00229	-0.000233	-0.0816***	0.0100**	0.000344
	(0.0220)	(0.00338)	(0.000797)	(0.0197)	(0.00420)	(0.000883)
Popu	0.0583***	0.00285***	-0.00124	0.0680***	0.00985***	-0.00126
	(0.0111)	(0.000927)	(0.000826)	(0.0128)	(0.00231)	(0.000835)
GDPg	0.0177***	0.00237	0.00186***	0.0170***	0.00254	0.00187***
	(0.00479)	(0.00243)	(0.000477)	(0.00468)	(0.00248)	(0.000481)
Open	0.00155***	0.000484***	-7.35e-05*	0.00183***	0.000728***	-8.52e-05*
	(0.000541)	(0.000123)	(4.25e-05)	(0.000534)	(0.000166)	(4.53e-05)
FDI	0.0700***	-0.0112***	-0.00217*	0.0681***	-0.0139***	-0.00215*
	(0.0188)	(0.00239)	(0.00116)	(0.0182)	(0.00300)	(0.00115)
Constant	-0.968***	0.136*	0.00694	-1.128***	0.0547	0.00836
	(0.330)	(0.0719)	(0.0175)	(0.349)	(0.0780)	(0.0175)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	6,481	13,287	6,261	6,451	13,207	6,244
R-squared	0.099	0.058	0.023	0.095	0.053	0.023

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

4.3 Testing the Inter-supply chain upgrading mechanism

Models (22) and (23) were then applied to test the features of the U-shaped distributed profit along the global supply chain and determine the inter-supply chain upgrading mechanism through which the profit might increase over time. The models were designed as follows.

$$PRO_{it} = \alpha + \beta TFP_{it} + \lambda TFP_{it}^{2} + \sum_{m} \gamma_m Country_{it} + \theta_i + \theta_t + \varepsilon_{it} \qquad (22)$$

$$PRO_{it} = \alpha + \beta TFP_{it} + \sum_{m} \gamma_m Country_{it} + \theta_i + \theta_t + \varepsilon_{it} \qquad (23)$$

where the explained variable PRO_{it} was the logarithm for the profit gained from industry *i* in country *c* in year *t*, TFP_{it} was the total factor productivity, $Country_{it}$ represented a set of country factors, θ_i and θ_t indicated the individual and time fixed effects, and ε_{it} was the error term. The OLS method with robust standard errors was used for the regression.

4.3.1 Full sample results

Columns (1)-(3) in Table 6 give evidence for the existence of the U-shaped curve. From columns (1) to (3), time and industry fixed effects were gradually added to the model. The regression coefficients for total factor productivity (*TFP*) were significantly and statistically negative across all specifications, while the quadratic terms were all significantly positive, which indicated that there was a U-shape relationship between *TFP* and the profit gained.

Columns (4)-(6) in Table 6 illustrate the upgrading effect between the *TFP* and the profit gained in each stage along the global supply chains. From column (4) to column (6), time and industry fixed effects were gradually added to the model. The results showed a positive relationship between *TFP* and profit, which indicated that the total factor productivity effectively upgraded and increased the profit gained in the stages; therefore, proposition 3 was verified.

Table 6. Dynamic effect of TFP and profit

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	*PRO*					
	U-shaped curve			Upgrading effect		
TFP	-0.248***	-0.249***	-0.256***	0.0667***	0.0669***	0.0773***
	(0.0312)	(0.0312)	(0.0334)	(0.00787)	(0.00794)	(0.00865)
TFP^2	0.0313***	0.0314***	0.0320***			
	(0.00387)	(0.00388)	(0.00397)			
Infra	-0.0197***	-0.0161**	-0.0152**	-0.0621***	-0.0563***	-0.0567***
	(0.00569)	(0.00669)	(0.00668)	(0.00847)	(0.00846)	(0.00839)
Tech	-0.0324***	-0.0320***	-0.0311***	-0.0181***	-0.0173***	-0.0227***
	(0.00654)	(0.00620)	(0.00572)	(0.00518)	(0.00478)	(0.00497)
Popu	-0.00351***	-0.00481***	-0.00378**	-0.0219***	-0.0230***	-0.0289***
	(0.00111)	(0.000916)	(0.00162)	(0.00244)	(0.00272)	(0.00315)
GDPg	-0.00135***	-0.000323	-0.000432	0.00304***	0.00593***	0.00572***

	(0.000383)	(0.00111)	(0.00111)	(0.000407)	(0.00145)	(0.00144)
Open1	0.000313***	0.000495***	0.000496***	4.19e-05	-0.000119	0.000169**
	(5.81e-05)	(0.000118)	(0.000113)	(3.49e-05)	(8.48e-05)	(8.38e-05)
FDI	0.0129***	0.0158***	0.0157***	0.000159	0.00271	0.00431
	(0.00315)	(0.00422)	(0.00408)	(0.00189)	(0.00298)	(0.00298)
Constant	0.661***	0.660***	0.722***	0.353***	0.333***	0.462***
	(0.0771)	(0.0780)	(0.0871)	(0.0464)	(0.0467)	(0.0679)
Year FE	NO	YES	YES	NO	YES	YES
Industry FE	NO	NO	YES	NO	NO	YES
Observations	28,915	28,915	28,915	28,915	28,915	28,915
R-squared	0.062	0.062	0.067	0.029	0.030	0.037

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

4.3.2 Subsample results

Whether there was a difference in the upgrading effect between countries that had different economic and human capital endowment levels was then determined. Columns (1)-(2) in Table 7 show the regression results for the developing and developed country subsamples, and columns (3)-(5) show the regression results for human capital endowments. All subsamples showed significant positive correlations between *TFP* and profit, which did not vary regardless of the country-level economic conditions and human capital heterogeneity

Table 7. Total factor productivity and profit (subsamples)

	(1)	(2)	(3)	(4)	(5)
Variable	*PRO* *developed*	*developing*	*High-HC*	*Mid-HC*	*Low-HC*
TFP	0.0238***	0.208***	0.141***	0.0503***	0.00378***
	(0.00200)	(0.0269)	(0.0216)	(0.0137)	(0.00143)
Infra	0.0238***	0.208***	0.141***	0.0503***	0.00378***
	(0.00200)	(0.0269)	(0.0216)	(0.0137)	(0.00143)
Tech	0.0111***	-0.0897***	-0.133***	-0.113***	0.00304*
	(0.00360)	(0.0192)	(0.0257)	(0.0250)	(0.00184)
Popu	0.00196**	-0.0685***	-0.0980***	0.00924**	-0.000763
	(0.000866)	(0.0111)	(0.0220)	(0.00386)	(0.000711)
GDPg	-0.00854***	-0.141***	0.0132*	-0.0121***	-0.00258**
	(0.000893)	(0.0176)	(0.00701)	(0.00462)	(0.00122)
Open	0.000606	0.0104***	0.0175***	0.00188	0.00182***
	(0.000546)	(0.00326)	(0.00475)	(0.00239)	(0.000466)
FDI	8.47e-05***	-0.00718***	0.00181***	0.000668***	-5.89e-05

	(2.47e-05)	(0.00116)	(0.000538)	(0.000146)	(3.96e-05)
Constant	0.0133	2.250***	-0.0781	0.420***	0.0250
	(0.0184)	(0.306)	(0.259)	(0.106)	(0.0200)
Year FE	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES
Observations	17,642	8,946	6,451	13,207	6,244
R-squared	0.068	0.069	0.087	0.052	0.024

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

5. Conclusions

This paper constructed a simple theoretical framework to illustrate the relevance of the smile curve hypothesis, which has been relatively unexplored in previous studies. A hierarchy assignment model was employed found that given a constant source of gains in labor costs, the dynamics of the average profitability in each firm in each stage in the supply chain was determined by the average product of labor and the relative ratio of output elasticity of capital to output elasticity of labor. To further explore the industrial upgrading mechanism, a new concept called the '*inter-supply chain upgrading mechanism'* was tested to prove that increases in both production complexity and factor intensity led to higher average profitability for all firms in the chain, thus making upgrading possible. Static and dynamic panel estimation empirical analyses were then conducted to corroborate the theories proposed in this paper. The conclusions drawn from this paper have far-reaching implications for the current debate on the division of the gains in the different countries participating in global supply chain-driven trade.

References

Arndt, S. W. "Globalization and the open economy." *North American Journal of Economics & Finance* (1997) Vol. 8. Issue.1, pp.71-79.

Arndt, S. W. "Super-specialization and the gains from trade". *Contemporary Economic Policy* (1998), Vol.16, Issue 4. pp.480-485.

Baldwin, R. and Gonzalez. J., ''Supply-Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses'', *The World Economy,* (2015) Vol.38, Issue 11. pp.1682-1721.

Costinot, A., Vogel, J., and Wang, S. "An elementary theory of global supply chains". *Review of Economic Studies* (2013), Vol.80. Issue1, pp. 109-144.

Dalamzzo. A., Pekkarinen .T, and Saramozzino. P, ''O-ring Wage Inequality''. *Economica*, New Series, Vol. 74, No.295 (2007), pp.515-536.

Hummels, D. L., Rapoport, D., & Yi, K. M., Vertical specialization and the changing nature of world trade. *Economic Policy Review*, (1998), 4(2), pp. 79-99.

Dixit, A. K., and Grossman, G. M. "Trade and Protection with multistage Production ", *The Review of Economic Studies*, (1982). Vol.49, Issue 4, pp.583-594.

Garicano, L., and Rossi-Hansberg, E., "Inequality and the organization of knowledge", *American Economic Review,* 94:2 (2004), pp197-202.

Garicano, L., and Rossi-Hansberg, E., "Organization and inequality in a knowledge economy", *Quarterly Journal of Economics*, 121:4 (2006), pp1383-1435.

Gereffi, G., and Korzeniewicz, M. Commodity chains and global capitalism. Westport, *Connecticut: Greenwood Press*, 1994.

Gereffi, G., Humphrey, J., and Sturgeon, T. "Commodity Chains and Global Capitalism" *London: Praeger*, 1994.

Gereffi, G. "International Trade and Industrial Upgrading in the Apparel Commodity Chain". *Journal of International Economics*, (1999). Vol.48, Issue 1, pp.37-70.

Gereffi, G., and Kaplinsky, R. ''Introduction: Globalization, Value Chains and Development'', *IDS Bulletin,* 32(3). pp.1-8.

Grossman, G. M., and Helpman, E., "Managerial incentives and International organization of production", *Journal of International Economics*, (2004), Vol.63, Issue 2. pp.237-262.

Grossman, G. M., and Helpman, E. ”Outsourcing in a global economy”, *Review of Economic Studies*, (2005). Vol.72, Issue 1. pp135-pp160.

Grossman, G. M., and Helpman, E. “Integration vs Outsourcing in industry equilibrium”. *The Quarterly Journal of Economics*, 2004, Vol.117 No.1, pp. 85-120.

Morris D., and Hay, D., Industrial Economics and Organization, London: *Oxford University Press*, 1991.

Humphrey, J., and Schmitz, H. “Governance in global value chains” *IDS Bulletin*, Vol.32, Issue 3, (2001). pp.19-29.

Humphrey, J., and Schmitz, H. “How does insertion in global value chains affect upgrading in industrial clusters”, *Regional Studies* (2002). Vol.36, Issue 9. pp27-pp43.

Ju, J., & Su, L. (2013). Market structure in the Chinese steel industry. *Asia-Pacific Journal of Accounting & Economics*, *20*(1), 70-84.

Ju, J., & Yu, X. (2015). Productivity, profitability, production and export structures along the value chain in China. *Journal of Comparative Economics*, *43*(1), 33-54.

Shen, J. H., Deng, K., & Tang, S. (2019). Re-evaluating the ‘smile curve’ in relation to outsourcing industrialization. *Emerging Markets Finance and Trade*, 1-24.

Lin, J. Y. (2012). *New structural economics: A framework for rethinking development and policy*. The World Bank.

Kaplinsky, R. “Spreading the gains from globalization: what can be learned from value chain analysis?” *Problems of Economics Transition* (2004), Vol.47, 2004. Issue 2. pp.74-115.

Kremer, M. “The O-Ring Theory of Economic Development”, *The Quarterly Journal of Economics,* 108:3 (1993), pp551-575.

Krugman, P. “Does Third World Growth Hurt First World Prosperity?” *Harvard Business Review,* (1994), Vol.72, Issue 4, pp113-139.

Lucas, R. “On the Size Distribution of Business Firms”, *Bell Journal of Economics*, 9:2 (1978), pp.508-523.

Mudambi, R., “Offshoring: economic geography and the multinational firms’’, *Journal of International Business Studies,* 38:1, pp.1-2, 2007.

Mudambi, R., “Location, control and innovation in knowledge-intensive industries’’, *Journal of Economic Geography,* 8:5, pp.699-725. 2008.

Marc J. M., and Ottaviano, G. ‘Market Size, Trade and Productivity’, *The Review of Economic Studies*, (2008), Vol.75, Issue 1. pp.295-316.

Shin, N., Kraemer, K. L. and Dedrick, J. “R&D, Value Chain Location and Firm Performance in the Global Electronics industry”, *Industry and Innovation* (2009) Vol.16, No.3, pp.315-330.

Shin, N., Kraemer, K. L., and Dedrick, J. “Value Capture in the Global Electronics Industry: Empirical Evidence for the “Smiling Curve” Concept*”, Industry and Innovation*, (2012). Vol.19, Issue 2, pp.89-107.

Rey, P., and Verge, T. ‘‘Bilateral Control with Vertical Contracts’’, *The Rand Journal of Economics,* 35:4. Winter. (2004). Pp.728-746.

Shih, S. (1996). Me-Too is Not My Style: Challenge Difficulties, Break through Bottlenecks, Create Values (Taipei: The Acer Foundation).

Verge, T, “Multi-product Monopolist and Full-Line Forcing: The Efficiency Argument Revisited.” *Economics Bulletin*, 12:4, (2001), pp1-9.

Ye, M., Meng, B., and Wei, S. J. ‘Measuring Smiling Curve in global value chain’, IDE discussion paper, No.530, 2015.