Working Paper Series

Department of Econom

ISSN 1753 – 5816

Please cite this paper as:

Shen, Jim HuangNan, Leilei Shen and Jun Zhang (2018), "Endowment Structure, Industry dynamics and Vertical Production Structure in China-Theory and Evidence", SOAS Department of Economics Working Paper No. 215, London: SOAS University of London.

No. 215

Endowment Structure, Industry Dynamics and Vertical Production Structure in China-Theory and Evidence

by

Jim. H. Shen (SOAS, University of London)
Leilei Shen (Kansas State University)
Jun Zhang (Fudan University)

(December 2018)

Department of Economics
SOAS University of London
Thornhaugh Street, Russell Square, London WC1H 0XG, UK
Phone: + 44 (0)20 7898 4730
Fax: 020 7898 4759
E-mail: economics@soas.ac.uk
http://www.soas.ac.uk/economics/

The **SOAS Department of Economics Working Paper Series** is published electronically by SOAS, University of London.

Endowment Structure, Industry dynamics and Vertical Production Structure in China-Theory and Evidence

Jim.H.Shen[*]
Leilei Shen[*]
Jun Zhang[†]

Abstract

This paper proposes a theoretical model and shows that the comparative advantage of China's factor endowment allows firms specializing in the midstream stage to gain at least as much as firms that specialize in the two ends of the supply chain (capital-intensive stage and labour-intensive stage) in terms of labour productivity and profitability, if and only if they have at least as much viability and use intermediate level of capital intensity. The empirical results are consistent with the theory's predictions. Our findings on China's industry supply chain production patterns provide a new angle on the division of gains in the vertical production network driven by the endowment structure. This could have far-reaching implications for the industrial development of other middle-income countries.

Keywords: Comparative Advantage, Factor Endowment Structure, labour-intensive, capital-intensive, industry chains, viability, labour productivity

JEL classification: F12, F23, F60, and L14

[*]SOAS University of London. Address for correspondence: Department of Economics, SOAS University of London. Russell Square, London WC1H 0XG, UK. Tel: +44 207 898 XXXX. Email: hs63@soas.ac.uk
[*] Department of Economics, Kansas State University, Email: lshen@ksu.edu
[†] China Center for Economic Studies, School of Economics, Fudan University, Email: junzh_2000@fudan.edu.cn

1. Introduction

This paper studies the role of factor endowment structure in shaping the division of the gains in China's industry supply chains.[3] While whether industrial policies in developing countries that encourage industrialization and industrial upgrading should conform to countries' comparative advantage is still under debate (Lin and Chang,2009), this paper provides a theoretical framework for deriving the conditions under which Chinese firms that conform to the comparative advantage in the intermediate capital-intensive stage could benefit at least as much as the vertically linked firms that defy the comparative advantage in the capital-intensive stage and labour-intensive stage in China's industry supply chain.

In this paper, we develop a hierarchy assignment model where the production process is split into three stages, with exclusive dealership among vertically-linked firms. In order to study profit sharing along the vertical production structure, we must remove the incentives for firms to vertically integrate with each other. We adopt the quantity fixing vertical restraint contracting choices, which is in line with the approach by Fontenay and Gans (2005,2014), Shen and Scaramozzino (2017), Shen, Liu and Chow (2016) and Shen, Zhang and Fang (2017). As a result, each vertically linked firm cannot reduce its output for marginalizing and the firms in the chains have no incentive to vertically integrate with each other. Production technology in each stage is Cobb-Douglas with labour and capital as inputs. Labour demand depends on firm's labour productivity and firm's viability in each stage. Wage is assumed to be higher in more upstream stages. In a supply chain with exclusive dealing and quantity fixing contract, profit maximization leads to an inverted U-shape in profitability and labour productivity from an increase in capital intensity. Our model shows that firms that specialize at midstream stage with intermediate level of capital-intensiveness gain the most, have the highest viability and labour-productivity compared to firms at capital-intensive upstream and labour-intensive downstream stages in the chain. The intuition behind this model is that given China is a middle-income country with its comparative advantage of endowment structure in the intermediate level of capital-intensiveness (neither labour-intensive nor capital-intensive), firms that are most profitable in the Chinese industry chains are those who operate within the production stages that are consistent with the current comparative advantage of endowment structure of Chinese economy.

We also explore how our theory can shed some new perspectives on the production patterns,

[3] It is worth noting that part of the definition of a Chinese industry chain is that all the firms within it, regardless of their ownership nature (foreign, SOEs or private), must all operate in China.

with regard to whether China tends to specialize in relatively upstream, midstream, or downstream industries, profits and labour productivity (Q/L), given China's industry capital intensities (K/L) in those industries. To achieve these objectives, we construct a measure of upstreamness following the same strategy proposed by Antràs, Chor, Fally and Hillberry (2012). Consistent with findings in Fally (2011), we find an industry's upstreamness is positively correlated with capital intensity in China. In addition, consistent with our model's predictions, we find that labour productivity and profit share peak when capital intensity is at the intermediate level and these industries are midstream industries in China. In other words, the relationship between profit share and capital intensity and labour productivity and capital intensity is inverted U-shaped. These findings are robust to the inclusion of additional set of controls.

The main contribution of this paper is that it not only recognizes the role of the level of viability of firms in sustaining their competitiveness in the industry supply chain, but also puts the factor endowment structure into the centre of the analytical framework. We show that firms with intermediate level of capital-intensiveness in China that conform to the comparative advantage by the economy's factor endowment is the main cause of their greater prosperity than Chinese firms specializing in the labour-intensive downstream and capital-intensive upstream stages in the supply chain that deviate from the current comparative advantage of China's factor endowment.[4] This closely captures the recent framework of new structural economics (NSE) developed by Lin (2012, 2015) and Ju, Wang and Lin (2015) who states a developing country ought to adopt a strategy of CAF in its industrial development, in order to catch up with more advanced economies.

The uneven distribution of gains along the supply chains has been analyzed by several papers in the literature (Gereffi,1994; Krugman, 1994; Costinot, Vogel and Wang, 2013; Dingra and Bernard, 2014; Liu, Shen and Chow, 2016; Baldwin et al, 2014; Basco and Mestieri, 2014); but most of these papers do not discuss the conditions under which such an uneven division of the gains in the supply chain will emerge. While most of the related works have focused on the profit sharing pattern among firms at the global level, and little work has been done on the

[4] According to the annual data published by the world bank in 2017, the annual GDP per capita (in dollars) of China is $8827, which makes China one of middle-income countries in the world. According to Lin (2012), for countries with low level of GDP per capita, their comparative advantage is labour and should specialize in the labour intensive stages in the supply chain, and for countries with high level GDP per capita, their comparative advantage is capital and should specialize in the capital-intensive stages in the supply chain. Middle-income countries ought to promote intermediate level of capital-intensive industries. Hence, since China is already a middle-income country, it is reasonable to assume that comparative advantage of Chinese economy lies in the intermediate level of capital-intensive industries.

division of gains along the industry supply chain within a country.

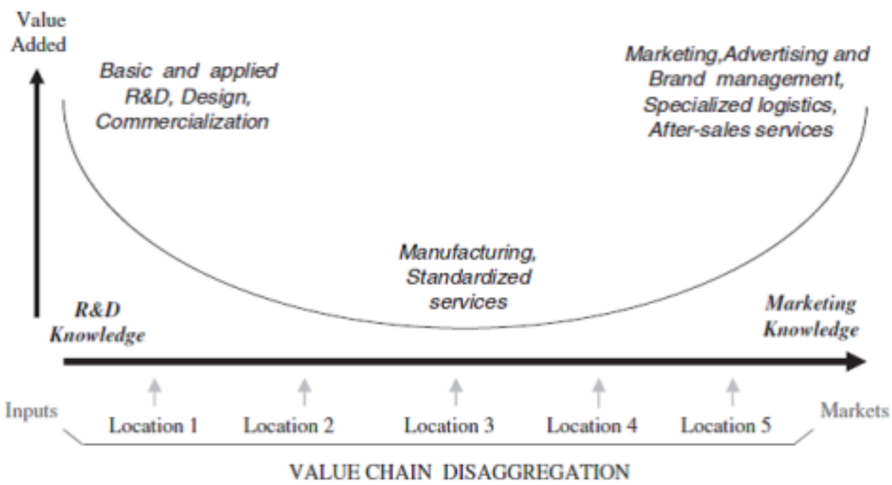
The rest of the paper is organized as follows. Section 2 provides the empirical motivation for our model. Section 3 reviews the literature. Section 4 sets up the model and generates the model's predictions. Section 5 provides the empirical support for the model. Section 6 concludes.

2. Empirical Motivation

2.1 Smile curve

The empirical motivation of this paper stems from the smile curve, which is widely discussed in the international business literature. The initial proponent of the smile curve, Stan Shih, the founder of ACER, pointed out that assembly firms in the global laptop supply chains earn much less than R&D and advertising firms. The idea of the smile curve is that the distribution of value-added of firms producing along the supply chains can be illustrated as a U-shaped curve in which the two ends of the supply chains, namely R&D and marketing, gain most, whereas the production stages in the middle, such as assembly or manufacturing, benefit less (Mudambi, 2007, 2008; Stan Shih, 1996; Ming, Meng &Wei, 2015). The following graph shows how the smile curve works.

Figure 1. Firm-level Smile Curve



Source: Smiling Curve of value creation (Mudambi, 2007)

Instead of using the term location in Figure 1, we use the term upstreamness (or the average distance from final use) from Antras, Chor, Fally, and Hillberry (2012) to measure the relative production position in each industry. If we simplify the production process into three stages,[5] in figure 1, R&D belongs to the upstream industry, marketing belongs to the downstream industry, and manufacturing belongs to the midstream industry. In addition, Fally (2011) show that a more upstream industry is more capital intensive, and we also find support for this positive correlation in our empirical results using Chinese data. In other words, in Figure 1, R&D is more upstream and capital intensive, marketing is more downstream and labour intensive, and manufacturing is midstream and has an intermediate level of capital intensity.

It is important to point out that while the smile curve may hold for value added, it may not be the case for profits. In other words, firms in midstream industries do not necessarily have lower profits than in other industries. Take the example of the Taiwan's laptop industry: after Acer started to specialize in upstream R&D and downstream marketing and advertising stages, Acer was no longer as profitable as it had been when it specialized in the manufacturing stage of chips and screen production (Tsai and Hung, 2006).

One possible explanation for the failure of Acer's shift to the R&D and marketing stages is that Acer deviated from the comparative advantage of Taiwan's factor endowment. By the late 1990s, Taiwan was no longer a labour-abundant economy nor was it as capital abundant as the US or other Western European countries.[6] Instead, one could argue that Taiwan's comparative advantage lies in the intermediate capital-intensive industries. As a result, it is possible that the failure of Acer's shift to the R&D and marketing and post-sale services stages largely results from specializing in stages in the supply chain that were not consistent with the comparative advantage of the endowment structure of Taiwan's economy at the time.

In contrast, the success of another Taiwan laptop firm, Quanta Computers, in the late 1990s, illustrates the importance of operating within industries that are consistent with the comparative advantage of the factor endowment structure of Taiwan's economy, which is

[5] We make this simplification here because our model also simplifies the production process into three stages to deliver tractable solutions. Our empirical results in section 5, however, are not constrained to only three production stages.

[6] Taiwan was a middle-income country/region by late 1990s. For countries with low level of GDP per capita, their comparative advantage is labour and should specialize in the labour intensive stages in the supply chain, and for countries with high level GDP per capita, their comparative advantage is capital and should specialize in the capital-intensive stages in the supply chain. Middle-income countries ought to promote intermediate level of capital-intensive industries. Hence, it is reasonable to assume that comparative advantage of Taiwan's economy lied in the intermediate level of capital-intensive industries in the late 1990s.

neither excessively capital-intensive nor labour-intensive. Quanta Computers persistently specialized in the high value-added parts of the manufacturing stage in the laptop chains, such as screen production and packaging, which are intermediate capital-intensive, and this led to higher profits and earnings. (Chang, Pan and Yu, 2008)

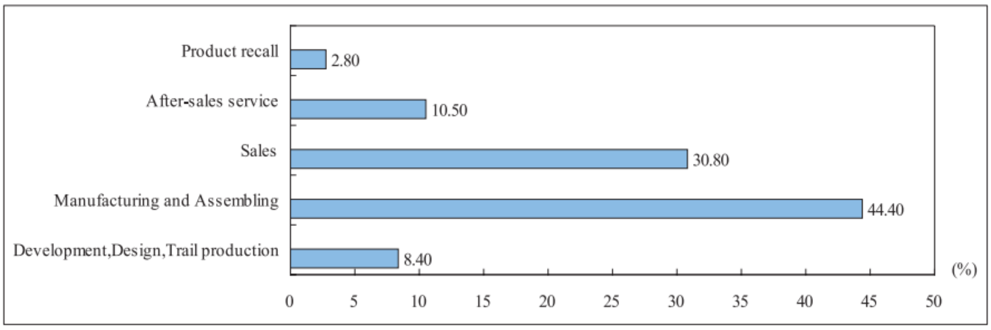
Profits have not been overlooked in the smile curve literature. For instance, Shin, Kraemer and Dedrick (2012) argue that in the value chain of the global electronics industry, lead firms (firms specializing in the marketing stage) and component suppliers (firms specializing in the R&D stage) earn higher gross margins and net margins than contract manufacturers do (firms specializing in the manufacturing stage). However, the differences vanish for the return on assets and the return on equity. These scholars argue that the cost of sustaining a position at either end of the curve is too high to make the returns on investment vary across the curve.

However, Shin, Kraemer and Dedrick (2012) do not take into account that cost differentials along the supply chains are endogenous. If firms from developing countries choose to operate within the production stages in the chains that are consistent with the comparative advantage of the endowment structure of the economy, the cost they incur is minimal whereas if firms from developing countries follow the industrialization strategy of defying comparative advantag, they incur higher costs and lose their competitiveness in the industry supply chain.[7]

If we focus on the profit sharing within a country's industry supply chains, the situation becomes even more complex. For instance, Wang and Chen (2014) find that the profit sharing along several Japanese manufacturing industry chains in the past decade is inverted U-shaped, based on the profit margin data of business segments in the publicly-traded Japanese Manufacturing companies from Japanese ministry of Economy, Trade and Industry. The following bar chart shows the detailed data of such profit sharing along the Japanese manufacturing industries:

Figure 2. Percentage of Profit Margins distribution along Japanese manufacturing industry chains

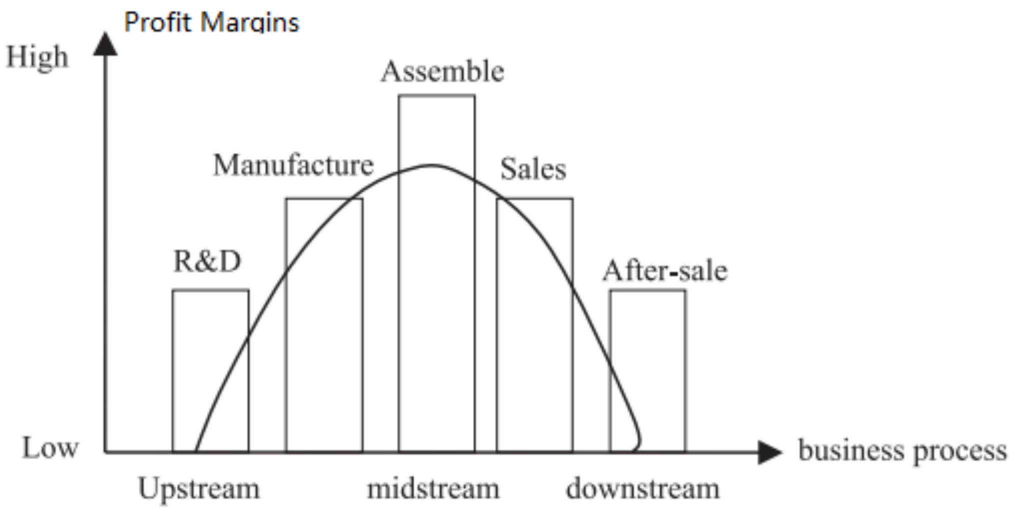
[7] The prevalence of the smile curve in the international business literature is prone to lead to the misunderstanding that if firms from developing countries stick to the non-excessively capital-intensive production stage such as heavy industries, R&D and so on, they always lose out, compared with firms from developed countries that specialize in either of the two ends of the curve. According to Lin and Sun (2009), the viability of firms and their capital accumulation are contingent upon the dynamic change in the comparative advantage of a country. It is true to say that at the global supply chain level, firms from developed countries specializing in excessively capital-intensive stages earn more than firms from low-income countries specializing in the more labour-intensive stage, but opportunities are also provided for developing countries in the future to accumulate the required capital for the industrial upgrading of the endowment structure.



Source: White Paper on Manufacturing Industries, Japanese Ministry of Economy, Trade and Industry

From figure 2, it can be seen that Manufacturing and Assembly parts of the industry chains have the highest profit-margins compared to the rest, which contradicts the smile curve. The following graph shows how such inverted U-shaped curve works for Japanese manufacturing industry chains:

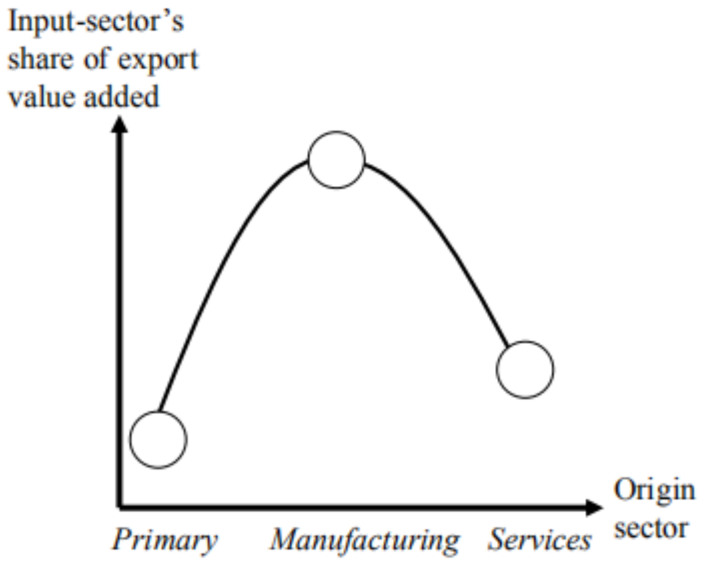
Figure 3. Inverted U-shaped curve for Japanese manufacturing industries



Source: Wang and Chen (2014)

In order to resolve this paradox, Baldwin.et.al (2014) make the distinction between economy-wide and firm-level division of the gains in the industry chains. They argue that the conventional validity of smile curve is based on firm level, which ignores the aggregate effect of profit sharing at the sectorial level. Using the data of newly released 2005 version of JETRO-IDE's Asian Input-Output (AIO) table, they construct the economy-wide division of the gains covering 76 domestic sectors for Asian regions including Indonesia, Malaysia, Philippines, Singapore, Thailand, China, Taiwan, Korea and Japan), they find that the midstream manufacturing sectors have higher gains than upstream primary and downstream service sectors in terms of input sector's share of export value added. The following graph illustrates the inverted U-shaped value-added sharing along the industry chains at the economy-wide level:

Figure 4. Economy-wide division of the gains in Asian regions

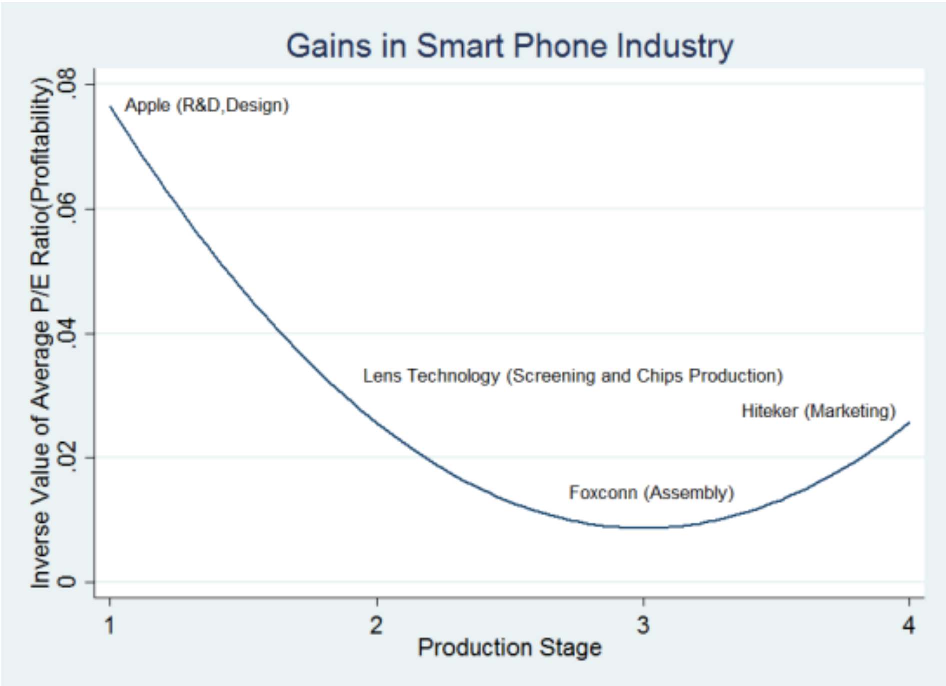


Source: Baldwin.et.al(2014)

Despite the fact that Baldwin.et.al (2014) make the distinction between firm level and sectorial level of smile curve, they do not further investigate why such inverted U-shaped curve at the sectorial level would emerge for regional industry chains. This paper fills this gap and shows the variation in profitability and labour productivity of different sectors along the industry chains is determined by whether these sectors are consistent with the comparative advantage of factor endowment structure of the economy.

We first estimate the profitability along the global iPhone industry chain to illustrate the idea that even in the global supply chains, comparative advantage of factor endowment across nations with different income levels determines the relative competitiveness of each vertically-linked firms. We apply the commonly used inverse value of the average 'Price-Earnings Ratio' (or 'P/E ratio' for short) from 2014 to 2016 as a proxy for firms' profitability. In corporate finance, the inverse value of the P/E ratio is equivalent to the earning yield for the companies in the stock market. The higher the average inverse value, the lower the P/E ratio. The profitability along the global iPhone industry chain is U-shaped:

Figure 5.The dynamics of profit sharing along iPhone industry chain



Source: Based on the authors' own calculations from Wind Information Database

The typical U-shaped pattern of the division of the gains exists for the iPhone industry because Foxconn produces in the excessively labour intensive assembly stage which deviates from China's comparative advantage in the intermediate capital-intensive industries.[8] Foxconn is less profitable than Apple because Apple specializes in the excessively capital-intensive stages, such as R&D, which is more consistent with US comparative advantage in the capital intensive industries. The recent business strategies adopted by Foxconn also support this argument. For assembly, Foxconn moved most of its factories in mainland China to other lower-income countries, such as Vietnam, Pakistan and Bangladesh, whose comparative

[8] By World Bank classification, China belongs to the middle-income country group. It is a well-known the fact that China's comparative advantage no longer lies in labour-intensive industries, and yet China is not as capital abundant as the US, therefore, China's comparative advantage is in the intermediate capital-intensive industries.

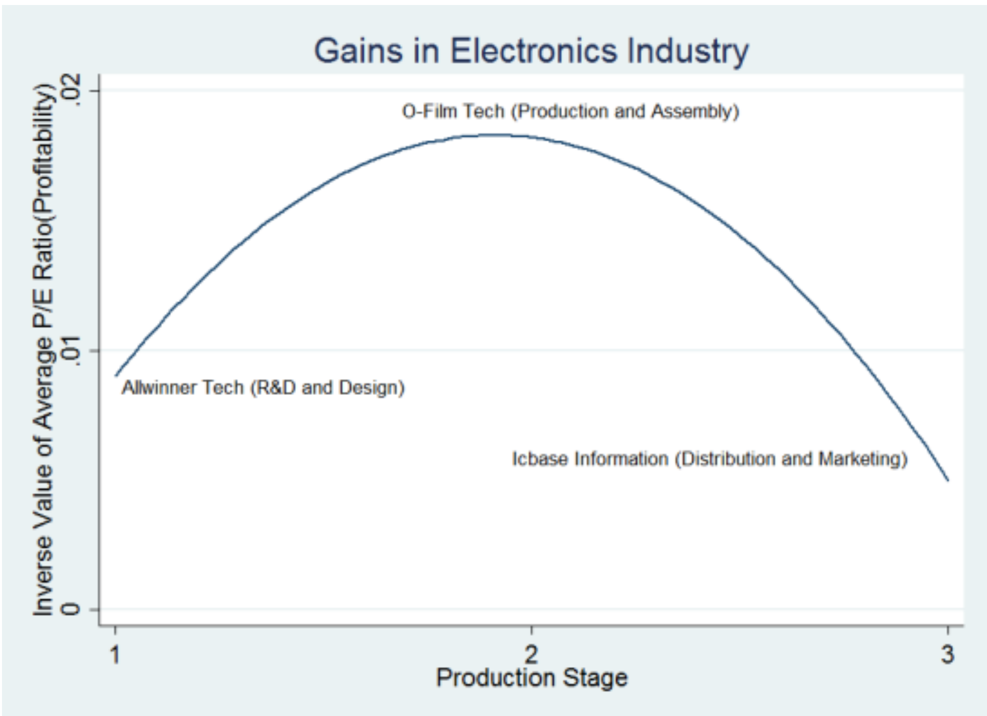
advantage is more consistent with the excessively labour-intensive nature of the assembly stage in the supply chain. In addition, Foxconn is also trying to upgrade its operations from assembly to other more capital-intensive stages in the iPhone chain, such as chips and screening production. By acquiring the Japanese electronics giant Sharp, Foxconn can operate at the stages that are consistent with the comparative advantage of the endowment structure of the Chinese economy.

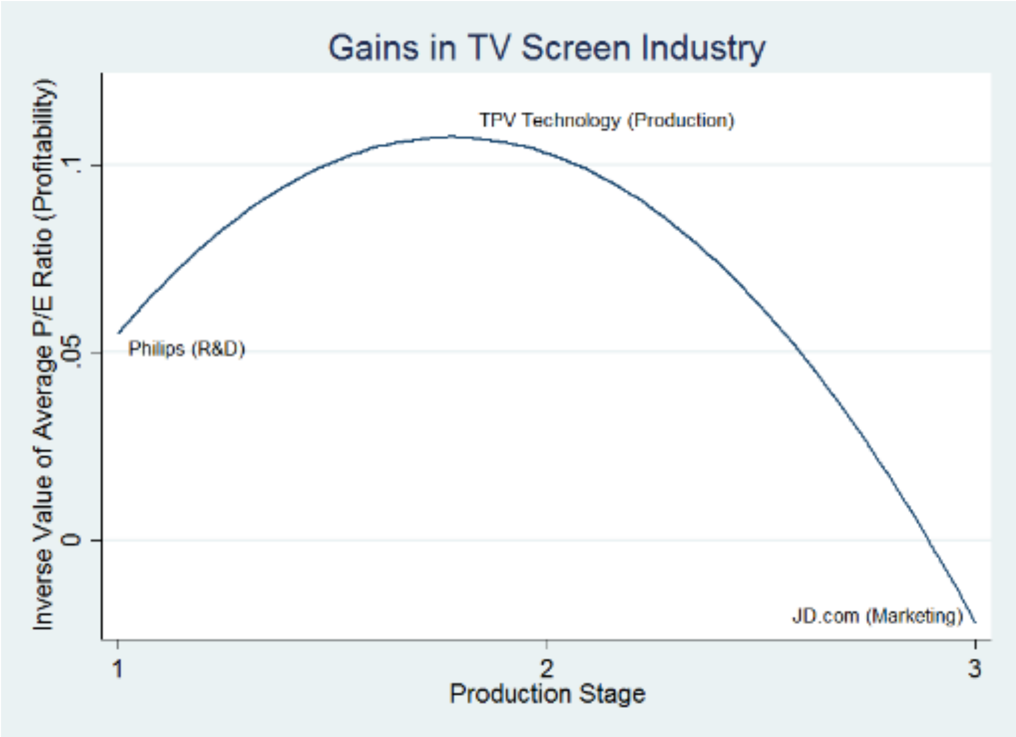
In contrast, Lens technology and Hiteker, receive higher returns than Foxconn. These two Chinese high-tech companies gain their competitiveness by operating within chips production and marketing stages, which are neither as capital-intensive as the R&D stage nor as labour-intensive as the assembly stage in the iPhone chain. The positions which these two high-tech companies occupy in the iPhone chain are more consistent China's comparative advantage in intermediate level of capital-intensive industries.

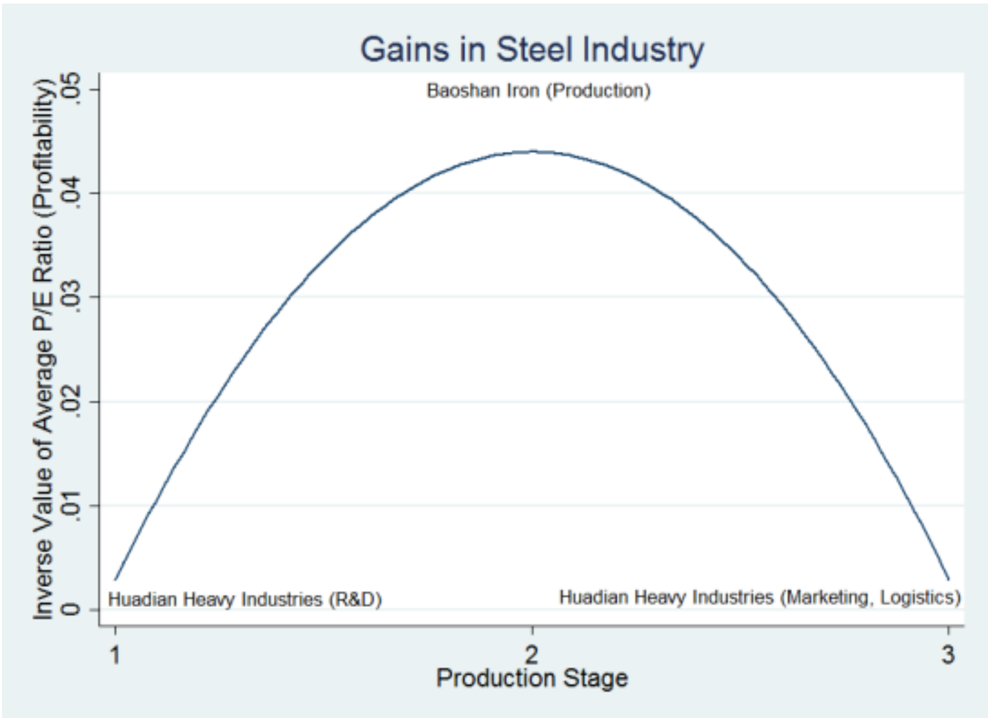
2.2 Some Stylized facts of Chinese industry chains

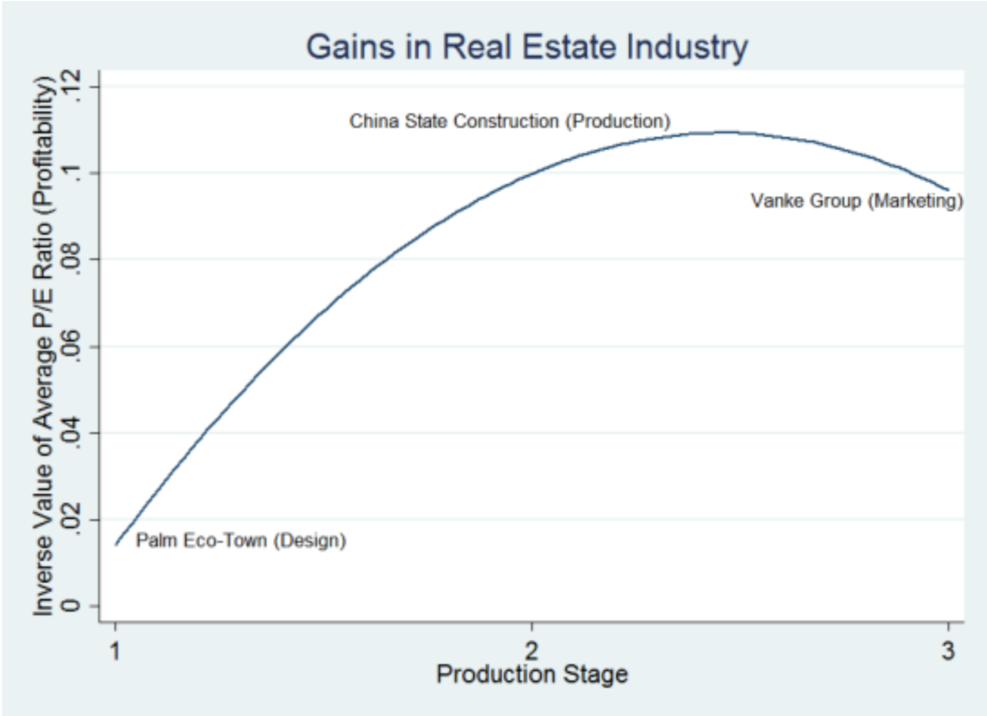
We estimate the profitability of firms along the five most representative industry supply chains in China from 2014 to 216 and find the profit sharing patterns to be inverted U-shaped as opposed to smile-curve shaped.

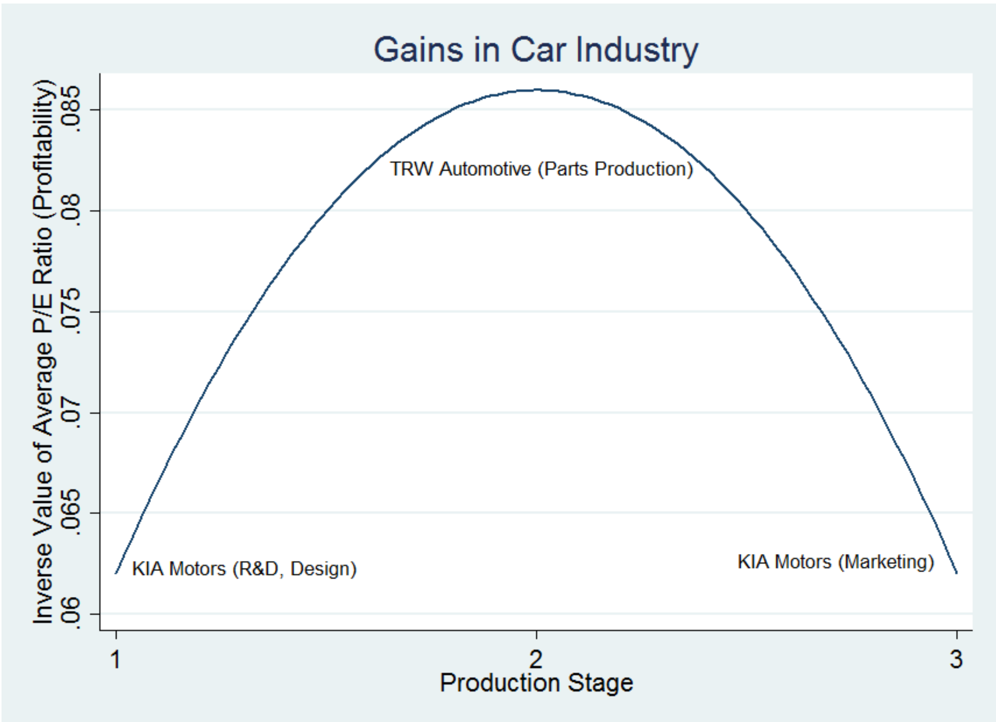
Figure 6. The dynamics of profit sharing along 5 Chinese industry chains




Gains in TV Screen Industry
TPV Technology (Production)
Philips (R&D)
JD.com (Marketing)
Inverse Value of Average P/E Ratio (Profitability)
0
.05
.1
1
2
3
Production Stage


Gains in Steel Industry
Baoshan Iron (Production)
Huadian Heavy Industries (R&D)
Huadian Heavy Industries (Marketing, Logistics)
Inverse Value of Average P/E Ratio (Profitability)
0
.01
.02
.03
.04
.05
1
2
3
Production Stage





Source: Based on the authors' own calculations from Chinese Industrial Enterprises, Chinese 2017 Statistical Yearbook.

In the electronics industry, O-firm High Tech specializes in production and assembly. It has the highest gains in the electronics chain because production and assembly has an intermediate level of capital intensity and specializing in these stages is more consistent with China's comparative advantage in the intermediate level of capital intensive industries. All Winner Tech and Icbase Information that specialize in the more capital-intensive R&D and labour-intensive marketing stages have lower profits than O-firm High Tech because China does not have comparative advantage in excessively capital-intensive and labour-intensive industries.

The other four Chinese industry chains shown above all exhibit the inverted U-shaped curve in which the firm in the middle earns more than those firms specializing in either of the ends of the chains. This is consistent with the China's comparative advantage in the intermediate capital-intensive industries. For instance, in the Chinese real estate industry, the midstream firm China State Construction Company is much more profitable than Palm-Eco Town and the Vanke Group that specialize in the design and marketing stages, respectively. A second example is the Chinese Steel Industry chain. The intermediate level of capital-intensive firm BaoShan Iron Company earns much more than the HuaDian heavy industries company, which specializes in the two ends of the chain. Moreover, the profit sharing along the Chinese TV Screen Industry chain exhibits the same inverted U-shaped pattern. The firm in the middle TPV technology earns much more than the upstream R&D firm Philips and the Chinese E-Commerce giant JD.com, a downstream marketing firm.[9] Finally, the division of the gains in the Chinese Car industry chain also exhibits the inverted U-shaped pattern in which the midstream TRW Automotive Company obtains the highest level of profitability unlike KIA Motors, which specializes in the two ends of the chains.

Having established an inverted U-shaped pattern between profitability and production stages using case studies, we review the literature in section 3, build a model in section 4 to explain the patterns observed above and provide empirical support to the model using more rigorous empirical analysis in section 5.

3.Literature Review

This paper stands at the intersection of three streams of literature. The first is the trade literature focusing on the way in which sequential production affects the division of the gains between the inter-connected nations at the global level (Melitz and Redding, 2015; Clare 2010; Arokolakis, Costinot and Clare 2012; Shen and Scaramozzino 2017, Shen, Deng and Fang 2016 ; Ju and Yu, 2015). The second stream is the global supply chain approach, from the perspective of the management and international business literature (Gereffi and Korzeniewicz 1994; Kaplinsky 2000). And lastly the New Structural Economics (NSE) literature focusing on the crucial nature of the comparative advantage of the factor endowment structure for the viability of firms in a competitive and open economy (Lin 2003, 2012; Lin and Tan 1999; Ju,

[9] It is worth mentioning that the Finnish firm Philips here is one that operates in China, where its R&D branch is also located. Therefore, its high capital-intensiveness is inconsistent with the comparative advantage of the factor endowment structure of Chinese economy, leading to its lower profitability.

Wang and Lin 2015, etc.)

This paper contributes to the sequential production literature in international trade theory. Most of the articles in the relevant field focus on the division of the gains from international trade, but have not paid enough attention to the division of the gains from vertical production structures in global trade. Although some papers, such as those by Shen and Scaramozzino (2017) and Shen, Zhang and Fang (2018), also discuss how the profits are shared among the various vertically linked firms in the supply chains, our paper differs fundamentally from them in two aspects: (1) Our main focus is on the domestic vertical production structure whereas those works consider profit sharing along the global supply chains; and (2) our paper puts the role of factor endowment structure at the centre of the analysis, whereas the above two works treat the entry cost and endogenous sunk cost as the key factors in shaping the division of the gains in supply chains. While Shen, Fang and Deng (2016) recognize the importance of the role of labour productivity in determining the division of the gains in supply chains, our paper goes one step further by asking what actually determines the higher labour productivity of some firms in the chains. The answer to this question lies in the comparative advantage of the factor endowment structure of the stages in the chains where the firms are located. Our result that firms specializing in intermediate capital-intensity stages are more profitable differs from Ju and Yu (2015), in which they find that more upstream firms are more profitable. One possible explanation for this difference may be that upstreamness measures in Ju and Yu(2015) are constructed based on manufacturing industries and the firms in their samples are only manufacturing firms. Our upstreamness measures, however, are constructed based on all Chinese industries in the input-output table.

Second, this paper is also closely linked to the management and international business literature on the global supply chains pioneered by Gereffi and Korzeniewicz (1994) and Kaplinsky (2000). They propose that the entry barriers of each production stage in the value chains largely affect the division of the gains between firms. Nonetheless, our paper further argues that such entry barriers ought to be endogenous to whether the stages where the firms operate are consistent with the comparative advantage of the factor endowment structure of the economy. In other words, if firms enter the industries that are in line with the comparative advantage of the local factor endowment structure, then they find fewer entry barriers and lower entry cost and, conversely, if firms enter the industries that defy comparative advantage, they find the opposite.

Lastly, we integrate the literature on the comparative advantage in a country's endowment structure with the sequential production literature in international trade theory. Lin and Tan (1999) and Lin (2003) propose that the viability of firms plays a key role in shaping the division of the gains in Chinese industry chains. Similarly, the paper by Ju, Wang and Lin (2015) propose to treat the dynamic upgrading of the factor endowment structure as the key reason for firms to accumulate capital as far as possible. According to their work, there exists the inverted U-shaped growth pattern of each industry. What sets this paper apart from previous work is that we incorporate the framework of sequential production into the analysis.

4. Model

4.1 Supply chains

Our model is inspired by the 'hierarchy assignment models' developed by several studies (Lucas, 1978; Rosen, 1982; Kremer, 1993; Garicano and Hansberg, 2004, 2006).The notation i is used such that the supply chain is split into three stages: $i\epsilon\{1,2,3\}$ corresponding to {upstream, midstream, downstream}. The upstream stage is assumed to be the most capital intensive, the downstream stage the most labour intensive, and the midstream stage has an intermediate level of capital intensity. We assume that each stage is in monopolistic competition with n_i firms.

4.2. Technology

The labour demand at the *i*th stage is defined as $L_i(q_i) = (q_i)^{f_i} l_i$, where $0 < f_i < 1$ and represents the level of viability of a firm at the *i*th stage in the chain.[10] l_i is the amount of labour required to produce output ${q_i}^{f_i}$ in the *i*th stage*;* the higher the l_i, more labour is required to produce the same amount of output. The rationale behind such a functional form of the labour demand function is that, in accordance with Lin (2003), if a firm in the chain has a high level of viability (that is, a higher value of *f*), then it is more consistent with the comparative advantage of endowment structure of the economy, which allows it to be more capable of absorbing a higher level of labour employment in the production stage.

Meanwhile, $w_i\ L_i(q_i)$ measures the labour cost for firms at the *i*th stage. The labour market at each particular stage is assumed to be perfectly competitive implying that all firms in a particular production stage face the same level of wages. The prices of intermediate goods are defined as p_i where i = 1, 2 and 3. It is assumed that upstream stages including R&D and heavy industries and midstream stages including productive service sectors and manufacturing sectors

[10] This exponential function form of output is firstly proposed by Dalmazzo,Pekkarinen and Scaramozzino (2007) in which they study the wage-inequality and technological complexity from the perspective of O-Ring theory.

are hiring more skilled workers with high wages. Downstream labour-intensive firms such as marketing, retailing or service industries employ less-skilled workers with lower wages. Hence, for all three stages, we propose the following assumption:

Assumption 1: At each production stage, wage level is monotonically decreasing in stage $i \in [1,2,3]$ such that $w_1 > w_2 > w_3$. The amount of labour required to produce the same amount of output is monotonically increasing in stage $i \in [1,2,3]$ such that $l_1 < l_2 < l_3$.[11]

In this paper, we assume that the technology available for all firms is a Cobb-Douglas production function Q=$L_i\ (q_i)^{\beta_i} K_i(q_i)\ ^{\alpha_i}$, for i = 1, 2 and 3, and constant returns to scale such that $\alpha_i + \beta_i = 1$. Furthermore, for the sake of obtaining the interior solution, we assume that $q_i \geq 1$ where *i=1,2 and 3*.

4.3 Contracting Choices

In line with the works of Bernard and Dhingra (2015) and Hart and Tirole (1990), in order to resolve downstream firms' moral hazard and free-riding problems arising from the competitive nature of production stages, which causes the lower joint-profitability in the vertical production structure, we adopt the exclusive dealing contracts in the chain to maximize the joint profits. Firms are in exclusive dealing relationship between each stage in the supply chain, where one upstream firm sells goods to one midstream firm, and one midstream firm sells goods to one downstream firm.[12] The best illustration of this is Apple's supply chain; it specializes in the upstream stage and the downstream stage and transacts only with Foxconn, which specializes in the assembly stage in the middle of the supply chain (Chan, Pun and Selden, 2013). Another example is China's electronics industry in which the upstream firm All-win Tech, the midstream firm O-Firm Tech and the downstream firm Icbase Information have relationships of one-to-one exclusive dealing. The main advantage of introducing exclusive dealing contracting is that it can eradicate the so-called "business stealing effect" in which the profit-sharing of each firm along the supply chains is heavily affected by the competitive nature of

[11] In a typical supply chain, most of the firms specializing in the upstream stage are undertaking R&D activities and thus generating a higher wage level than is seen in the firms in the middle, which specialize in high-value added or advertising work. The same logic holds true between the firms in the middle of the chain and the marketing firms in the downstream stages of the chain.. The stylized facts regarding more R&D-intensive firms paying higher wages are also supported by some of the very recent empirical literature, such as Aghion, Bergeaud, Blundell and Griffith (2017).

[12] Marvel (1982) defines exclusive dealing as a contractual requirement by which retailers or distributors promise a supplier that they will not handle the goods of competing producers. According to Meza and Selvaggi (2007), any clause that explicitly prohibits one of the contracting parties from dealing with non-contracting counterparts can be deemed as intrinsically exclusive.

the market structure of each production stage.[13][14]

In the model, it is assumed that the upstream firm specifies the equilibrium level of output in the exclusive dealing contract in which the midstream and downstream firms are obliged to produce and the upstream firm does not receive a fixed payment for this contract. The reason for making this simplification is to avoid the double marginalization problem within the vertical production structure. (Rey and Stiglitz, 1994). To eliminate the inefficiencies arising from the double marginalization, we adopt the quantity fixing vertical restraint contracting choices, which is in line with the approach by Fontenay and Gans (2005,2014), Shen and Scaramozzino (2017), Shen, Liu and Chow (2016) and Shen, Zhang and Fang (2017).

Many of the recent scholars on international trade have analysed the determinants of outsourcing and vertical integration strategies when the production stages are globally dispersed (Antràs and Helpman, 2008; Acemoglu et al., 2009; Antràs and Chor, 2013; Costinot et al., 2013; Alfaro et al., 2018). However, unlike these scholars, we must remove the incentives for firms to vertically integrate with each other in order to study the firm-level profit sharing along the vertical production structure. In this paper, if we adopt the quantity fixing imposed by one firm in the chain, each vertically linked firm cannot reduce its output for marginalizing and therefore the firms in the chains have no incentive to vertically integrate with each other. This then leads to the second assumption in this paper:

Assumption 2: The ex-post output in all stages is equal: $q_1 = q_2 = q_3 = q^*$.[15]

More importantly, the idea of this exclusive dealership is that it is the first-best output which can maximize the joint profits of all the firms producing along the supply chains. In other words, q^* specified in the contract is the unique solution which solves the following problem:

$$q^* = \underbrace{argmax}_{\{q_i\}_{i=1}^{3}} \left[\sum_{i=1}^{3} \mathrm{p}_i q_i - rK_i(q_i) - w_i L_i(q_i)\right]$$ [16]

[13] The 'business steal effect' was a name first coined by Dingra and Bernard (2015) in their NBER working paper, in which they proposed the idea that some firms in the global trade benefit less because they operate within a more competitive market, where there are other similar firms that steal some of their market share.

[14] The removal of "business stealing effect" could largely explain the difference between the conclusions derived from our model and the ones from Ju and Yu(2015). Ju and Yu (2015) argue that the profitability and capital-intensity are higher for Chinese upstream industries compared with downstream industries. Such higher profitability of upstream industries, from our point of view, could be the result of high monopolistic market power enjoyed by the firms in these upstream industries.

[15] This condition implies a fixed supply function at each stage. Stigler first recognised this condition in an industry cycle; see G. Stigler, 'The Division of Labor is Limited by the Extent of the Market', *The Journal of Political Economy,* 59/3 (1951), pp. 185-93.

[16] The reason for assuming the constant rate of interest across stages is that it is one way to differentiate between regional supply chains and global ones. For the global level supply chains, the cost of capital must be

4.3 Solution

The profit function for a representative firm at the *i*th stage is found in:

$$\pi_i(q_i) = \mathrm{p}_i q_i - rK_i(q_i) - w_i L_i(q_i) \tag{1}$$

Similarly, the profit function for the firm at the *i*+1th stage can be written as follows:

$$\pi_{i+1}(q_{i+1}) = \mathrm{p}_{i+1} q_{i+1} - rK_{i+1}(q_{i+1}) - w_i L_{i+1}(q_{i+1}) \tag{2}$$

The optimization problem at the *i*th stage can be expressed as:

$$\underbrace{Max}_{\{q_i\}_{i=1}^{3}} \ \pi_i(q_i) = \mathrm{p}_i q_i - rK_i(q_i) - w_i L_i(q_i) \tag{3}$$

Take the derivative of (3) with respect to q, to obtain

$$\frac{\partial \pi_i(q_i)}{\partial q_i} = p_i - r\frac{\partial K_i(q_i)}{\partial q_i} - w_i\frac{\partial L_i(q_i)}{\partial q_i} = 0 \tag{4}$$

Therefore,

$$p_i = r\frac{\partial K_i(q_i)}{\partial q_i} + w_i\frac{\partial L_i(q_i)}{\partial q_i} \tag{5}$$

With $L_i(q_i) = q^{f_i} l_i$, $q = L_i(q_i)^{\beta_i} K_i(q_i)^{\alpha_i}$, we can rewrite $K_i(q_i)$ as

$$K_i(q_i) = (q_i)^{\frac{1-\beta_i f_i}{\alpha_i}} \left[l_i^{-\frac{\beta_i}{\alpha_i}} \right] \tag{6}$$

Plug (6) into (5), profit-maximizing price at the *i*th stage is the following:

different between different stages since each stage is assigned to different countries throughout the world. Nonetheless, for any domestic economy, it is reasonable to assume that there exists a unified banking system which sets a uniform interest rate in the domestic market. The Chinese case is no exception. Hence, in this paper, we assume that all firms in the domestic supply chains face a uniform interest rate, regardless of the positions they occupy in the chains.

$$p_i = f_i(q_i)^{f_i-1}w_i\, l_i + \frac{r[1-\beta_i f_i]}{\alpha_i} \times (q_i)^{\frac{\beta_i(1-f_i)}{\alpha_i}} \left[l_i^{-\frac{\beta_i}{\alpha_i}} \right] \quad (7)$$

Divide (3) by q_i on both sides:

$$\frac{\pi_i(q_i)}{q_i} = p_i - w_i \frac{L_i(q_i)}{q_i} - r \frac{K_i(q_i)}{q_i} \quad (8)$$

Plug (7) into (8):

$$\frac{\pi_i(q_i)}{q} = f_i q^{f_i-1} w_i\, l_i + \frac{r[1-\beta_i f_i]}{\alpha_i} \times [q_i]^{\frac{\beta_i(1-f_i)}{\alpha_i}} \left[l_i^{-\frac{\beta_i}{\alpha_i}} \right] - w_i \left[\frac{L_i(q_i)}{q_i} \right] - r \frac{K_i(q_i)}{q_i}$$

(9)

Equation (9) can be written as:

$$\frac{\pi_i(q_i)}{q_i} = \frac{r\beta_i(1-f_i)}{\alpha_i} l_i^{-\frac{\beta_i}{\alpha_i}} \times [q_i]^{\frac{\beta_i(1-f_i)}{\alpha_i}} - [1-f_i]\ \frac{w_i L_i(q_i)}{q_i} \quad (10)$$

The mathematical expression for average profitability at the *i*th stage becomes:

$$\frac{\pi_i(q_i)}{q_i} = \underbrace{\frac{r\beta_i(1-f_i)}{\alpha_i}\left[\frac{q_i}{L_i(q_i)}\right]^{\frac{\beta_i}{\alpha_i}}}_{capability\ effect\ \ for\ the\ firm\ at\ the\ ith\ stage} - \left\{ \underbrace{[1-f_i]\frac{w_i L_i(q_i)}{q_i}}_{Average\ variable\ cost\ effect\ \ of\ a\ firm\ \ at\ the\ ith\ stage} \right\}$$

(11)

From (11), it can be seen that the average profitability function consists of two effects: The first is the capability effect, which captures the level of the average labour product of the firm. The second is the average variable cost effect. Both of these two effects are largely contingent upon the viability level of the firm.

With the fixing quantity q^*, the ex-post profit at the *i*th stage is therefore:

$$\frac{\pi_i(q^*)}{q^*} = \underbrace{\frac{r\beta_i(1-f_i)}{\alpha_i}\left[\frac{q^*}{L_i(q^*)}\right]^{\frac{\beta_i}{\alpha_i}}}_{capability\ effect\ \ for\ the\ firm\ at\ the\ ith\ stage} - \left\{ \underbrace{[1-f_i]\frac{w_i L_i(q^*)}{q^*}}_{Average\ variable\ cost\ effect\ \ of\ firm\ \ at\ the\ ith\ stage} \right\}$$

(12)

Similarly, ex-post average profitability at the *i+1th* stage is:

$$\frac{\pi_{i+1}(q^*)}{q^*} = \underbrace{\frac{r\beta_{i+1}(1-f_{i+1})}{\alpha_{i+1}}\left[\frac{q^*}{L_{i+1}(q^*)}\right]^{\frac{\beta_{i+1}}{\alpha_i+1}}}_{capability\ effect\ \ for\ the\ firm\ at\ the\ ith\ stage} - \left\{\underbrace{[1-f_{i+1}]\frac{w_{i+1}L_{i+1}(q^*)}{q^*}}_{Average\ variable\ cost\ effect\ \ of\ a\ firm\ \ at\ the\ ith\ stage}\right\}$$

(13)

Using (12) and (13), proposition 1 can be derived**:**

The profitability curve becomes flat when $\frac{\pi_1(q^*)}{q^*} = \frac{\pi_2(q^*)}{q^*}$and $\frac{\pi_3(q^*)}{q^*} = \frac{\pi_2(q^*)}{q^*}$.

This leads to Proposition 1 (the flat profitability curve)**:**

Proposition 1: *In a supply chain with fixing quantity q^*, the average profitability becomes less differentiated if the following conditions are satisfied:*

$$\begin{cases}\frac{q^*}{L_1(q^*)} = \frac{q^*}{L_2(q^*)}\ if\ and\ only\ if\ \ \frac{K_1(q^*)}{L_1(q^*)} > \frac{K_2(q^*)}{L_2(q^*)}\ . \\ \qquad f_2 \geq f_1\end{cases}$$

$$\begin{cases}\frac{q^*}{L_3(q^*)} = \frac{q^*}{L_2(q^*)}\ if\ and\ only\ if\ \ \frac{K_2(q^*)}{L_2(q^*)} > \frac{K_3(q^*)}{L_3(q^*)}\ . \\ \qquad f_2 \geq f_3\end{cases}$$

For the proof of proposition 1, please see Appendix A. .

Most interestingly, the return curve can be in an inverse U-shaped pattern if $\frac{\pi_1(q^*)}{q^*} < \frac{\pi_2(q^*)}{q^*}$, and$\frac{\pi_3(q^*)}{q^*} < \frac{\pi_2(q^*)}{q^*}$. This leads to proposition 2 in this paper:

Proposition 2 *(inverted-U shaped curve)***:** *In a supply chain with fixing quantity q^* the average profitability of firms at different stages exhibits an inverse U if the following conditions are satisfied:*

$$\begin{cases}\frac{q^*}{L_1(q^*)} < \frac{q^*}{L_2(q^*)}\ if\ and\ only\ if\ \ \frac{K_1(q^*)}{L_1(q^*)} > \frac{K_2(q^*)}{L_2(q^*)}\ . \\ \qquad f_2 \geq f_1\end{cases}$$

$$\begin{cases}\frac{q^*}{L_3(q^*)} < \frac{q^*}{L_2(q^*)}\ if\ and\ only\ if\ \ \frac{K_2(q^*)}{L_2(q^*)} > \frac{K_3(q^*)}{L_3(q^*)}\ . \\ \qquad f_2 \geq f_3\end{cases}$$

Please see Appendix B for the proof of proposition 2.

Based on propositions 1 and 2, we find the conditions for the flat and the inverted U-shaped profitability curves to hold. The mid-upstream firm not only has to have a higher (equal) viability level than the upstream and downstream firms, but also has to be in more capital-intensive than the downstream firms and less capital-intensive than upstream firm to sustain its higher labour productivity. That is to say, the capital-intensiveness of mid-upstream has to be intermediate.

If firms from middle-level income developing economies participate in the midstream manufacturing stage of the chain, its factor endowment structure must be at the intermediate level of capital-intensity, such that these firms could be as profitable as or more profitable than the capital-intensive upstream and labour-intensive downstream firms. This argument is consistent with Lin's (2012) argument that a developing economy ought to use its comparative advantage in the factor endowment structure in terms of promoting its comparative-advantage to follow industries that can make most profits and become most viable. According to our theory, firms in a middle-income country participating in the intermediate level of capital-intensive industries along the industry supply chain could gain as much profitability as the firms specializing in the two ends of the chains, if not more.

5. Empirical Evidence

We explore how our theory can shed some new perspectives on production patterns, with regard to whether China tends to specialize in relatively upstream or downstream industries, profits and output per labour (Q/L) in those industries, given China's industry capital intensities (K/L). To achieve these objectives, we construct a measure of upstreamness following the same strategy proposed by Antràs, Chor, Fally and Hillberry (2012) (hereafter referred to as ACFH 2012). In an open economy, the position of an industry's output in the value chain is given by the following:

$$Y_i = F_i + Z_i + X_i - M_i = F_i + \sum_{j=1}^{N} \hat{d}_{ij} Y_j = F_i + \sum_{j=1}^{N} \hat{d}_{ij} F_j + \sum_{j=1}^{N} \sum_{k=1}^{N} \hat{d}_{ik} \hat{d}_{kj} F_j + \cdots, \quad (14)$$

where for each industry $i \in \{1,2 \dots, N\}$, the value of gross output Y_i equals the sum of its final good use (F_i) and intermediate input use (Z_i) plus exports (X_i) minus imports (M_i). In the summation, $\hat{d}_{ij}$ is the domestic absorption of sector i's output to produce one dollar's worth of industry j's output. In particular, $\hat{d}_{ij}$ is constructed as follows:

$$\hat{d}_{ij} = d_{ij} \frac{Y_i}{Y_i - X_i + M_i},$$

where d_{ij} is the dollar amount of sector i's output needed to produce one dollar's worth of industry j's output.[17] As shown in ACFH 2012, iterating this, we can express industry i's output as an infinite sequence of terms which reflect the use of this industry's output at different positions in the value chain. The upstreamness of industry i is as follows:

$$U_i = 1 \cdot \frac{F_i}{Y_i} + 2 \cdot \frac{\sum_{j=1}^{N} \hat{d}_{ij} F_j}{Y_i} + 3 \cdot \frac{\sum_{j=1}^{N} \sum_{k=1}^{N} \hat{d}_{ik} \hat{d}_{kj} F_j}{Y_i} + \cdots. \quad (15)$$

5.1 Empirical Specification

Proposition 2 in the theory section leads us to estimate the following specifications:

$$U_{it} = \beta_1 KL_{it} + \alpha_t + \varepsilon_{it},$$
$$Profit_{it} = \gamma_1 KL_{it} + \gamma_2 KL_{it}^2 + \alpha_t + \varepsilon_{it},$$
$$Q/L_{it} = \delta_1 KL_{it} + \delta_2 KL_{it}^2 + \alpha_t + \varepsilon_{it}, \quad (16)$$

where KL_{it} is the capital-labour ratio (or capital intensity, hereafter used interchangeably) for industry i at time t. U_{it} is upstreamness, $Profit_{it}$ is profit share, defined as profits divided by total value added, and Q/L_{it} is output per labour (or labour productivity, hereafter used interchangeably), defined as total value added divided by total wages for labour for industry i at time t. α_t is the time fixed effects. Our model predicts that when capital intensity is at the intermediate level, production that takes place is more midstream, there is more output per labour generated, and profit share is higher. In other words, $\hat{\beta}_1 > 0$, $\hat{\gamma}_1$ and $\hat{\delta}_1 > 0$, and $\hat{\gamma}_2$ and $\hat{\delta}_2 < 0$.

Alongside capital-labour intensities, trade protection measures such as tariffs and non-tariff barriers, U.S. industry characteristics such as assets, advertising and R&D expenditures, and costs of capital and wages may explain differences in the dependent variable. We consider these factors using an augmented specification as follows:

$$U_{it} = \beta_1 KL_{it} + +\boldsymbol{X}_{it}\boldsymbol{\Gamma}_\mathbf{1} + \alpha_t + \varepsilon_{it},$$
$$Profit_{it} = \gamma_1 KL_{it} + \gamma_2 KL_{it}^2 + \boldsymbol{X}_{it}\boldsymbol{\Gamma}_\mathbf{2} + \alpha_t + \varepsilon_{it},$$
$$Q/L_{it} = \delta_1 KL_{it} + \delta_2 KL_{it}^2 + \boldsymbol{X}_{it}\boldsymbol{\Gamma}_\mathbf{3} + \alpha_t + \varepsilon_{it}, \quad (17)$$

where $\boldsymbol{X}_{it}$ is a vector of additional time-varying industry characteristics, and α_t controls for

[17] $\hat{d}_{ij}$ is constructed based on the proportionality assumption, such that the share of industry i's exports (imports) that are used by industry j producers is identical to the share of industry i's output used in industry j, at home or abroad.

time fixed effects which absorb the changes in costs of capital and wages.[18]

5.2 Data

The previous section made it evident that our main objective is to investigate the relationship between China's production patterns and capital-labor ratio. To achieve this objective, we employ data from China's Input-Output Table in 2002, 2007, and 2012 obtained from Statistics China.[19] We construct industry-consistent crosswalks across three years at 3-digit industry level and end up with 111 industries, out of which 20 are agricultural, mining and food and beverages industries, 58 are manufacturing industries, and 33 are service industries.

We use the algorithm provided by ACFH 2012 to construct the upstreamness measure for each industry based on China's Input-Output Table in 2002, 2007, and 2012. Table C1 in Appendix C lists the average upstreamness for 111 industries.[20] The measure of upstreamness ranges from the 1.03 (public administration and social works) to 5.69 (non-ferrous metal mining). The most downstream industries are service industries with almost all of their output directly going to final use. Mining industries are among the most upstream industries and enter into production processes roughly four stages before final use. Midstream industries include many manufacturing industries and enter into production processes roughly two stages before final use. The upstreamness of an industry also equals to the increase in the dollar amount of all output industries from a one dollar increase in value-added in that industry (ACFH 2012).

We construct the capital-labor ratio from the IO tables based on value-added capital depreciation and labour wages for each industry. Profit share is constructed using profit in the industry divided by the total value added in the industry. We employ additional controls that vary over industry and time, such as tariffs and non-tariff barriers, U.S. industry characteristics such as assets, advertising and R&D expenditures, obtained from Brandt, Van Biesebroeck, Wang and Zhang (2017).[21]

Table 1 provides the summary statistics for the main variables used in the empirical analysis. At the upper section of this table, we report the mean, standard deviation, min and max for the dependent variables. The mean across 111 industries and 3 years is 3.10 with standard deviation 1.10. The average industry therefore enters into production processes two

---

[18] We do not include industry fixed effect because there is not enough within industry variation over time for K/L.

[19] IO tables for China are available for some other years but they are at 2-digit industry level.

[20] We also compute upstreamness for industries excluding agricultural and mining industries, the most downstream industries are still service industries, and the most upstream industries tend to be involved in processing raw materials. Our empirical results are similar and are available upon request.

[21] We constructed the crosswalks between the industry definitions in Brandt, Van Biesebroeck, Wang and Zhang (2017) to our industries.

stages before final use. The average profit share is 25% and the average labour productivity is 2.94, or 2.94 dollars total value added for every one dollar spent on labour. The lower section of this table reports the summary statistics for the right-hand-side variables. The average capital-labor ratio is 0.44 with standard deviation 0.50.[22] US industry controls such as assets, advertising and R&D are in millions of US dollars and the reported summary statistics are in logs. Trade protection measures include dummy variables on if the industry in China prohibits or restricts FDI and the industry's applied and maximum output and input tariffs. Note that the US industry measures from Brandt, Van Biesebroeck, Wang and Zhang (2017) are time invariant, and the trade protection measures are not available for service industries. We set these variables to 0 to avoid dropping those industries when we estimate the augmented models in equation (17).

Table 1 Summary Statistics

	Mean	St. Dev.	Min	Max	N
Dependent variables					
Upstreamness	3.10	1.10	1.00	6.18	333
Profit share	0.25	0.15	-0.27	1.00	333
Q/L	2.94	3.97	0.98	67.07	332
Independent variables					
K/L	0.44	0.50	0.01	4.79	332
Assets (log)	4.20	0.28	3.21	4.88	177
Advertising (log)	-0.02	0.90	-1.78	1.95	177
R&D (log)	0.02	1.04	-2.30	1.72	177
FDI prohibited	0.02	0.07	0.00	0.40	118
FDI restricted	0.12	0.23	0.00	1.00	118
applied output tariff	11.48	7.88	0.00	44.04	118
applied input tariff	7.36	2.85	2.63	16.76	118
max output tariff	12.18	8.63	0.00	48.22	118
max input tariff	7.74	3.21	2.64	18.94	118

The linear correlation between profit share and capital intensity and labour productivity and capital intensity is fairly weak. The correlation coefficient between capital intensity and profit share and capital intensity and labor productivity in the industry is 0.09 and 0.13, respectively. In contrast, the linear correlation between upstreamness and capital intensity is stronger, and the correlation coefficient is 0.35. To motivate our econometric specification in equation (16), we first plot the locally smoothed industry upstreamness and capital-labor ratio

[22] In year 2002, one industry reports value-added from labor to be zero, and therefore K/L is missing for that industry. Therefore, there are only 110 observations in year 2002, and a total of 332 observations for K/L.

in Figure 7.[23] The relationship between industry upstreamness and capital intensity is upward sloping, although upstreamness seems to peak when capital intensity is larger than 0.7. Consistent with our theory, the relationship between profit share and capital-labor ratio is inverted U-shaped, as shown in Figure 8. Lastly, Figure 9 shows that relationship between labour productivity (Q/L) and capital intensity is also inverted U-shaped. To our knowledge, the non-monotonicity of capital intensity on profit share and labour productivity has not been documented before and our theory offers to explain the reasoning behind the non-monotonicity. In the following econometric exercises, we approximate the non-monotonicity using equation (16) and it is our goal to show that the non-monotonicity is robust to the inclusion of additional controls.

Figure 7 Upstreamness and K/L Ratio

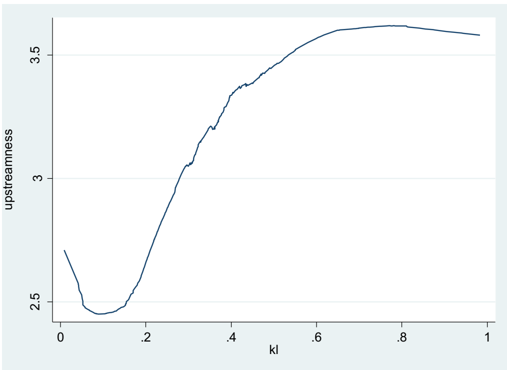


Figure 8 Profit Share and K/L Ratio

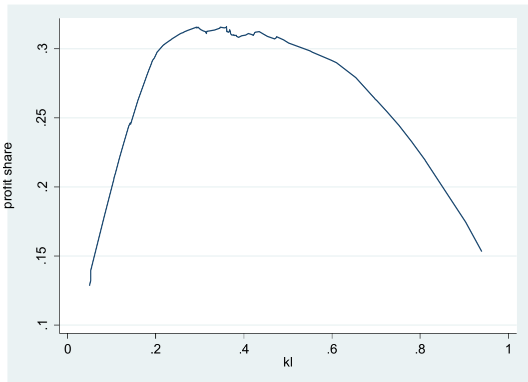
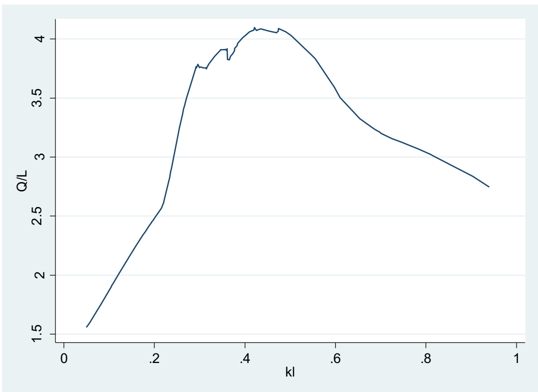


Figure 9 Q/L and K/L Ratio



5.3 Empirical Results

We estimate equation (16) where the dependent variable is upstreamness, defined in equation (15) and report the results in Table 2. In columns (1) to (3), we estimate the effect of

[23] We drop a few industries that are outliers in capital intensity and therefore limit to those industries with K/L<1. This accounts for roughly 95% of the industries in the data. In the regression analysis, we report the results for the full sample as well as the sample without outliers.

K/L on upstreamness in each year separately, and in column (4), we report the results using all years. In all four columns, we find the capital intensity to have a positive but insignificant effect on the upstreamness of an industry.[24] However, these results may be driven by outliers. In columns (5) to (8), we provide the empirical results when we drop the outlier industries and limit the industries to K/L less than one, which account for 95% of the data. Capital intensity now has a positive and significant effect on upstreamness. This is consistent with findings in Fally (2011) for US industries. This implies that when capital intensity is at the intermediate level, production that takes place also tends to be more midstream.

Table 2 Upstreamness and K/L

	All				K/L<1			
	2002	2007	2012	Pooled	2002	2007	2012	Pooled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
K/L	0.44*	0.04	0.28	0.20	1.59***	1.73***	2.35***	1.89***
	(0.26)	(0.23)	(0.44)	(0.19)	(0.40)	(0.45)	(0.48)	(0.26)
Time FE	-	-	-	Yes	-	-	-	Yes
Observations	110	111	111	332	101	105	108	314
R-squared	0.04	0.00	0.01	0.05	0.13	0.09	0.18	0.18

Notes: Robust standard errors are reported. *** Significant at 1%, ** significant at 5%, * significant at 10%.

The theory predicts that firms have more to gain by specializing in more midstream industries in the value chain if they have greater viability and use intermediate level of capital intensity. We use industry's profit share, defined as before, to measure firms' gains, and report estimates from equation (16) in Table 3. Columns (1) to (4) report results using the full sample, and columns (5) to (8) report the results dropping the outlier industries. Columns (5) to (8) suggest there is a very strong non-monotonic relationship between capital intensity (K/L) and profit share. Using point estimates from column (8), profit share peaks when K/L is equal to 0.49. To further ensure that the relationship between profit share and K/Lis not linear, we also estimate equation (16) by omitting the K/L squared term, and the coefficient for K/L is no longer significant and very close to 0 for all columns.[25] Using point estimate form column (8) in Table 2, when K/L is equal to 0.49, the upstreamness of the industry is between 2.98 and 3.59, between 2002 and 2012. The combination of the results from Tables 2 and 3 support our

[24] If we include K/L squared term, both K/L and K/L squared are significant in columns (1) to (4), and the coefficient for K/L is positive, and the coefficient for K/L squared is negative. However, based on these estimates, this suggests that upstreamness peaks when K/L is equal to 1.82, which is two standard deviations above the mean in capital intensity. In fact, 99% of the industries have K/L <1.82. Therefore, our theory that when K/L is at the intermediate level, the industry is more midstream holds. These results are available upon request.

[25] We also perform the robustness checks by omitting the K/L squared terms for labour productivity regression. Doing so makes the linear term insignificant and close to 0. These results are available upon request.

theory's prediction that production becomes more midstream for intermediate level of capital intensity due to higher profitability.

Table 3 Profit Share and K/L

	All				K/L<1			
	2002	2007	2012	Pooled	2002	2007	2012	Pooled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
K/L	0.03	0.06	0.19***	0.07*	0.37*	0.91***	0.63**	0.65***
	(0.09)	(0.08)	(0.07)	(0.04)	(0.23)	(0.30)	(0.24)	(0.15)
$(K/L)^2$	-0.01	-0.01	-0.05***	-0.02**	-0.40*	-1.02***	-0.56**	-0.67***
	(0.04)	(0.02)	(0.02)	(0.01)	(0.23)	(0.31)	(0.26)	(0.16)
Time FE	-	-	-	Yes	-	-	-	Yes
Observations	110	111	111	332	101	105	108	314
R-squared	0.00	0.01	0.06	0.05	0.03	0.11	0.09	0.11

Notes: Robust standard errors are reported. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Proposition 2 predicts higher labour productivity when the capital intensity is at the intermediate level. We show in Table 4 that when capital intensity is at the intermediate level, labour productivity is in fact higher. We use output per labour as the dependent variable and report the results in Table 4. Similar to the effect of K/L on profit share, the non-monotonic relationship exists between K/L and Q/L. Using the point estimates in column (8), output per labour peaks when K/L is equal to 0.61.

Table 4 Q/L and K/L

	All				K/L<1			
	2002	2007	2012	Pooled	2002	2007	2012	Pooled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
K/L	3.60***	2.55**	2.71***	2.53***	4.66***	16.25*	6.85***	8.99***
	(1.26)	(1.21)	(0.53)	(0.50)	(1.15)	(9.47)	(1.82)	(3.09)
$(K/L)^2$	-0.91*	-0.27	-0.29**	-0.28**	-1.73	-16.35	-5.04**	-7.42**
	(0.52)	(0.25)	(0.12)	(0.12)	(1.60)	(10.53)	(2.33)	(3.51)
Observations	110	111	111	332	101	105	108	314
R-squared	0.24	0.02	0.14	0.06	0.17	0.02	0.08	0.04

Notes: Robust standard errors are reported. *** Significant at 1%, ** significant at 5%, * significant at 10%.

We have established the basic non-monotonic relationship between K/L and profit share and K/L and labour productivity, and the linear relationship between K/L and upstreamness. However, other factors that vary over industry and time may explain variations in the dependent variables. Using a control function approach, we control for time variant trade protection measures such as tariffs and non-tariff barriers, FDI restrictions in Chinese industries, and time invariant U.S. industry characteristics such as assets, advertising and R&D expenditures, obtained from Brandt, Van Biesebroeck, Wang and Zhang(2017). We estimate equation (17) and report the results in Table 5 . Columns (1) and (2) suggest that when capital intensity is at the intermediate level, production that takes place is more midstream. Columns (3) and (4) suggest that when capital intensity is at the intermediate level, profit share is higher. Although the squared terms in columns (5) and (6) are not significant at 10%, the point estimates are not significantly different from those in columns (8) in Table 4, and based on the point estimates in column (6) Table 5, the labour productivity peaks when K/L is equal to 0.53, which is at the intermediate level of capital intensity.

Table 5 Augmented Model: K/L <1

	Upstreamness		Profit Share		Q/L	
	(1)	(2)	(3)	(4)	(5)	(6)
K/L	1.91***	1.92***	0.67***	0.68***	11.39*	12.56*
	(0.23)	(0.24)	(0.18)	(0.19)	(6.33)	(6.65)
$(K/L)^2$			-0.69***	-0.70***	-10.02	-11.90
			(0.19)	(0.20)	(7.00)	(7.39)
US industry controls						
Assets	0.02	0.06	-0.00	0.01	-0.15	-0.11
	(0.03)	(0.04)	(0.00)	(0.01)	(0.20)	(0.15)
Advertising	-0.33***	-0.23***	0.00	0.00	0.21	0.13
	(0.07)	(0.07)	(0.01)	(0.01)	(0.19)	(0.12)
R&D	0.13**	0.09	0.01*	0.01	-0.06	0.01
	(0.06)	(0.06)	(0.01)	(0.01)	(0.08)	(0.08)
Trade protection measures						
Nontariff		1.11		-0.21**		-2.82*
barriers		(0.68)		(0.08)		(1.66)
FDI prohibited		2.33**		-0.03		-3.99*
		(0.90)		(0.15)		(2.36)
FDI restricted		0.38		-0.03		2.57**
		(0.29)		(0.04)		(1.29)
applied output		0.22*		-0.06**		0.30
tariff		(0.12)		(0.02)		(0.36)
applied input		-0.34		0.01		-3.24*
tariff		(0.37)		(0.06)		(1.95)
max output		-0.24**		0.06**		-0.17
tariff		(0.11)		(0.02)		(0.31)
max input		0.32		-0.02		2.83
tariff		(0.33)		(0.05)		(1.75)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	314	314	314	314	314	314
R-squared	0.25	0.28	0.11	0.14	0.04	0.07

Notes: Robust standard errors are reported. *** Significant at 1%, ** significant at 5%, * significant at 10%.

6. Conclusions

We establish a hierarchy assignment model and divide the supply chains into the 3 stages to investigate profit sharing along the supply chains. Our model reveals how operating within the comparative advantage consistent production stages in the chain could deliver both higher viability and labour productivity level for firms, which in turn generate higher profitability.

Our empirical results support the model's predictions that profitability and labour productivity are the highest in the intermediate capital-intensive industries which is consistent with China's current comparative advantage in the intermediate capital-intensive industries.

Given the upstreamness of Chinese industry chains and capital-intensity are positively correlated, the most profitable Chinese firms in the industry chains tend to specialize in the midstream stage of the chain. The congruence between comparative advantage of endowment-structure of Chinese economy and the locations at which most profitable firms in China locate in the industry chains is the key in determining the growth of Chinese economy.

References

Alfaro, L, P. Antràs, D. Chor, and P. Conconi. Forthcoming. 'Internalizing Global Value Chains: A Firm-Level Analysis.' *Journal of Political Economy*, 2018.

Alberto Dalmazzo, Tuomas Pekkarinen and Pasquale Scaramozzino, 'O-Ring Wage Inequality', *Economica*, New Series, Vol. 74, No. 295 (Aug., 2007), pp. 515-536

Acemoglu, D, S. Johnson and T.Mitton, 'Determinants of Vertical Integration: Financial Development and Contracting costs', *Journal of Finance*. Vol. LXIV, No.3, June, (2009), pp.1251-1286.

Aghion, P, A.Bergeaud, R.Blundell and R.Griffth, 'Innovation, Firms and Wage Inequality', Department of Economics, Harvard University, *Working Paper Series,* https://scholar.harvard.edu/files/aghion/files/innovations_firms_and_wage.pdf

Anon., 'Chinese industrial Sectors', *Wind Information* online database www.wind.com, available on 20th November, 2016.

Anon., 'Concepts and Methods of the U.S. Input-Output Accounts', https://www.bea.gov/papers/pdf/IOmanual_092906.pdf, updated in April 2009.

Antràs, Pol, and Elhanan Helpman, "Global Sourcing," *Journal of Political Economy*, 112 (2004), pp.552–580.

Antràs, P., D. Chor, T. Fally and R. Hillberry (2012), 'Measuring the Upstreamness of Production and Trade Flows', *The American Economic Review*, 102 (3) pp. 412-16.

Antràs, Pol, and Davin Chor. 'Organizing the Global Value Chain', *Econometrica*, 81/6 (2013), pp. 2127-2204.

Aoki, Masahiko and Ando Haruhiko, *Mojuruka: Atarashii Sangyo Akitekucha no Honshitsu* (*Modularity, the Nature of A New Industrial Structure*) (Toyo: Economic New Press, 2002).

Arkolakis C, A. Costinot and A.Clare, 'New Trade Models, Same Old Gains', *American Economic Review,* 102(1) (2012): pp.94-130..

Baldwin, R, Tadashi Ito and Hitoshi Sato, 'The Smile Curve: Evolving Sources of Value Added in manufacturing', March, (2014), unpublished paper, available online in November 2016 at http://www.uniba.it/ricerca/dipartimenti/dse/e.g.i/egi2014-papers/ito.

Basco, S and Marti Mestieri, 'The World Income Distribution: The Effects of International Unbundling of Production', *TSE Working Papers*, no. 14–531 (2014), Toulouse School of Economics.

Bernard, A. and S. Dhingra, 'Contracting and the Divisions of the Gains from Trade', *NBER Working Paper*, no. 2169, 2015.

Brandt, L., J. Van Biesebroeck, L. Wang and Y. Zhang (2017). 'WTO Accession and

Performance of Chinese Manufacturing Firms', *American Economic Review*, 107 (9), pp. 2784—2820.

Costinot, Arnaud, Jonathan Vogel and Su Wang, 'An Elementary Theory of Global Supply Chains', *Review of Economic Studies*, 80 (2013), pp. 109–44.

Clare, R. 'Offshoring in a Ricardian World', *American Economic Journal Macroeconomics,* (2010), 2(2): pp.227-258.

De Meza, and M. Selvaggi, 'Exclusive Contracts Foster Relationship-Specific Investment', *Rand Journal of Economics,* (2007), 38(1), pp.85-97.

De Fontenay, Catherine, and Joshua Gans , 'Vertical Integration in the Presence of Upstream Competition', *Rand Journal of Economics*, (2005),35(3): pp.544-572.

De Fontenay, Catherine, and Joshua Gans, 'Bilateral Bargaining with Externalities', *Journal of Industrial Economics*, (2014),62(4):pp.756-788.

Fally. T, 'On the fragmentation of production in the US', *Freit working paper series,* 2011.

Garicano, L. and E. Rossi-Hansberg, 'Inequality and the Organization of Knowledge', *American Economic Review*, 94/2 (2004), pp. 197-202.

Garicano, L. and E. Rossi-Hansberg, 'Organization and Inequality in a Knowledge Economy', *The Quarterly Journal of Economics*, 121/4 (2006), pp. 1383-1435.

Gereffi, Gary and Miguel Korzeniewicz, *Commodity Chains and Global Capitalism* (Westport: Greenwood Press, 1994).

Gereffi, Gary, 'International Trade and Industrial Upgrading in the Apparel Commodity Chain', *Journal of International Economics*, 48 (1999), pp. 37–70.

Guofu Tan & Justin Yifu Lin, "Policy Burdens, Accountability, and the Soft Budget Constraint," *American Economic Review*, American Economic Association, (1999), vol. 89(2), pp. 426-431, May,

Grossman, Gene M. and Elhanan Helpman, 'Integration vs Outsourcing in Industry Equilibrium', *Quarterly Journal of Economics*, 117/1 (2002), pp. 85–120.

Grossman, Gene M. and Elhanan Helpman, 'Outsourcing in a Global Economy', *Review of Economic Studies*, 72 (2005), pp. 135–59.

Hart, O. and J. Tirole, 'Vertical Integration and Market Foreclosure', *Brookings Papers on Economic Activity, Microeconomics*, Special Issue (1990), pp. 205-76.

http://data.worldbank.org/data-catalog/world-development-indicators.

Hummels, David, Dana Rapopport and Kei-Mu Yi, 'Vertical Specialization and the Changing Nature of World Trade', *Economic Policy Review*, June (1998), pp. 79–99.

Humphrey, John and Hubert Schmitz, 'How Does Insertion in Global Value Chains Affect Upgrading in Industrial Clusters', *Regional Studies*, 36 (2002), pp. 1017–27.

Jim.H, Shen and P. Scaramozzino, 'A bilateral Monopoly Model of Profit Sharing along the Global Supply Chains' *Freit working paper series,*2017.

Jim.H. Shen, Lei Fang and Kent Deng, 'Re-Evaluating the 'Smile Curve' in Relation to Outsourcing Industrialization', *SSRN Working Paper Series*, 2016.

Jim.H.Shen, Lei Fang and Jun Zhang, 'A Contracting Approach to the Division of the Gains in Global Supply Chains-Theory and Evidence', *SSRN Working Paper Series, 2018*.

Justin Yifu Lin, 'Development Strategy, Viability, and Economic Convergence,' *Economic Development and Cultural Change*, University of Chicago Press, vol. 51(2),2003, pp. 276-308, January,.

Justin, Yifu Lin, Cai, Fang and Li, Zhou, . 'Competition, Policy Burdens, and State-Owned Enterprise Reform,' American Economic Review, American Economic Association, vol. 88(2), (1998), pp. 422-427, May.

Justin Yifu Lin and Xifang Sun, 'Banking structure and economic growth: Evidence from China,' *Frontiers of Economics in China, Higher Education Press*, vol. 4(4), pp. 479-504, December. 2009.

Justin, Yifu, Lin, 'New Structural Economics: A Framework for Rethinking Development', *the World Bank Research Observer,* Published by Oxford University Press, 2012.

Justin Yifu, Lin and Ha-Joon Chang, 'Should Industrial Policy in Developing Countries conform to Comparative advantage or defy it? A debate between Justin Lin and Ha-Joon Chang, *Development Policy Review,* Overseas Development Institute, vol. 27(5), (2009) pp. 483-502, September.

Jiandong Ju, Justin, Yifu, Lin and Yong Wang, 'Endowment structures, industrial dynamics, and economic growth', *Journal of Monetary Economics* , v. 76, November (2015), pp. 244-263

Jiandong Ju and Xinding Yu, 'Productivity, profitability, production and export structures along the value chains in China', *Journal of Comparative Economics*, 43(1): (2015),pp.33-54,

J.Tsai and H, -Y.Hung, 'International brand strategy of Taiwanese hi-tech enterprises', *Agricultural Economics, (*2007), 53(2): pp.83-88.

Kaplinsky, Raphael, 'Spreading the Gains from Globalization: What Can Be Learned from Value Chain Analysis?' *IDS Working Paper*, no. 110 , 2000.

Kremer. M, 'The O-Ring Theory of Economic Development', *The Quarterly Journal of Economics,*(1993), Vol. 108, No.3, Aug, pp.551-575.

Krugman, Paul, 'Does Third World Growth Hurt First World Prosperity?' *Harvard Business Review*, July/August (1994), pp. 113–21.

Lucas, R., ‘On the Size Distribution of Business Firms’, *Bell Journal of Economics*, 9/2 (1978), pp. 508-23.

Liu, Xiaojie and Jim H. Shen and Chow, Peter, ‘Demystifying the Global Supply Chain - A Smiling Curve Perspective’. Available at SSRN: https://ssrn.com/abstract=2864895, *SSRN working paper series*, November 5, 2016

Masahiko Aoki and Ando Haruhiko, *Mojuruka: Atarashii Sangyo Akitekucha no Honshitsu* (*Modularity, the Nature of a New Industrial Structure*) (Toyo: Economic New Press, 2002).

Marvel, Howard P. (1982) "Exclusive Dealing," *Journal of Law and Economics: Vol*. 25 : No. 1 , Article 2.

Melitz,M and S. Redding. “ New Trade Models, New Welfare Implications.” American Economic Review 105 (3): *American Economic Review* (2015) 105 (3): pp.1105-46.

Mudambi, R., ‘Global Innovation in MNCs: The Effects of Subsidiary Self-Determination and Teamwork’, *Journal of Product Innovation Management,* 24/5 (2008), pp. 442-55.

Mudambi, R., ‘Location, Control and Innovation in Knowledge-intensive Industries’, *Journal of Economic Geography,* 8/5 (2007), pp. 699-725.

Rey, P. and T. Verge, ‘Bilateral Control with Vertical Contracts’, *Rand Journal of Economics*, 35 (2004), pp. 728-46.

Rey, P and J. Stiglitz, ‘The role of Exclusive Territories in Producers’ Competition’, *Rand Journal of Economics,* (1995),vol.26, No.3, Autumn, pp.431-451.

Rosen, S., ‘Authority, Control and the Distribution of Earnings’, *Bell Journal of Economics*, 13/2 (1982), pp. 311-23.

Shih, S. *Me-Too is Not My Style: Challenge Difficulties, Breakthrough Bottlenecks, Create Values*. Taipei: Acer Foundation, 1996.

Shin, Namchul and Kenneth L. Kraemer, ‘Value Capture in the Global Electronics Industry: Empirical Evidence for the ‘Smiling Curve’ Concept’, *Industry and Innovation*, 19/2 (2012), pp. 89–107.

Shih-Chi Chang, Lee-Yun Pan and Hsiao-Cheng Yu , ‘The Competitive Advantage of Quanta Computer- The World’s leading notebook PC manufacturer in Taiwan’, *Total Quality Management & Business Excellence,* 19:9, (2008), pp.939-948,

Stigler, G., ‘The Division of Labor is Limited by the Extent of the Market’, *The Journal of Political Economy*, 59/3 (1951), pp. 85-193.

Sutton, J and D.Trefler ‘Capabilities, Wealth, and Trade’, *Journal of Political Economy*, 124/3 (2016), pp. 826–78.

Wang Qian and Cheng du, 'Should China's Manufacturing Industry Transition Towards Both Ends of the Smiling Curve?- A Comparative Analysis between China and Traditional Manufacturing Powers' , *China Economist,* vol.9, No.1, January-February, (2014), pp.22-30.

Ye, Ming, Bo Meng and Shang-jin Wei, 'Measuring Smiling Curve in Global Value Chain', *IDE Discussion Papers*, no. 530 , 2015.

Acknowledgments

We wish to thank comments from Robert Wade, Justin Yifu Lin, John Sutton, Pol Antras, Shangjin Wei, Daniel Trefler, Luis Garicano, Gary Jefferson, Dic Lo, David De Meza, Maushik Basu, Pasquale Scaramozzino, Catherine Thomas, Ricardo Alonso, XiaoJie Liu, Guanghua Wan, Jiandong Ju and many others. All the remaining errors are of our own. We particularly thank the editorial assistance from Dr Eric Golson.

Table 1 Summary Statistics

	Mean	St. Dev.	Min	Max	N
Dependent variables					
Upstreamness	3.10	1.10	1.00	6.18	333
Profit share	0.25	0.15	-0.27	1.00	333
Q/L	2.94	3.97	0.98	67.07	332
Independent variables					
K/L	0.44	0.50	0.01	4.79	332
Assets (log)	4.20	0.28	3.21	4.88	177
Advertising (log)	-0.02	0.90	-1.78	1.95	177
R&D (log)	0.02	1.04	-2.30	1.72	177
FDI prohibited	0.02	0.07	0.00	0.40	118
FDI restricted	0.12	0.23	0.00	1.00	118
applied output tariff	11.48	7.88	0.00	44.04	118
applied input tariff	7.36	2.85	2.63	16.76	118
max output tariff	12.18	8.63	0.00	48.22	118
max input tariff	7.74	3.21	2.64	18.94	118

Table 2 Upstreamness and K/L

	All				K/L<1			
	2002	2007	2012	Pooled	2002	2007	2012	Pooled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
K/L	0.44*	0.04	0.28	0.20	1.59***	1.73***	2.35***	1.89***
	(0.26)	(0.23)	(0.44)	(0.19)	(0.40)	(0.45)	(0.48)	(0.26)
Time FE	-	-	-	Yes	-	-	-	Yes
Observations	110	111	111	332	101	105	108	314
R-squared	0.04	0.00	0.01	0.05	0.13	0.09	0.18	0.18

Notes: Robust standard errors are reported. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Table 3 Profit Share and K/L

	All				K/L<1			
	2002	2007	2012	Pooled	2002	2007	2012	Pooled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
K/L	0.03	0.06	0.19***	0.07*	0.37*	0.91***	0.63**	0.65***
	(0.09)	(0.08)	(0.07)	(0.04)	(0.23)	(0.30)	(0.24)	(0.15)
$(K/L)^2$	-0.01	-0.01	-0.05***	-0.02**	-0.40*	-1.02***	-0.56**	-0.67***
	(0.04)	(0.02)	(0.02)	(0.01)	(0.23)	(0.31)	(0.26)	(0.16)
Time FE	-	-	-	Yes	-	-	-	Yes
Observations	110	111	111	332	101	105	108	314
R-squared	0.00	0.01	0.06	0.05	0.03	0.11	0.09	0.11

Notes: Robust standard errors are reported. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Table 4 Q/L and K/L

	All				K/L<1			
	2002	2007	2012	Pooled	2002	2007	2012	Pooled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
K/L	3.60***	2.55**	2.71***	2.53***	4.66***	16.25*	6.85***	8.99***
	(1.26)	(1.21)	(0.53)	(0.50)	(1.15)	(9.47)	(1.82)	(3.09)
$(K/L)^2$	-0.91*	-0.27	-0.29**	-0.28**	-1.73	-16.35	-5.04**	-7.42**
	(0.52)	(0.25)	(0.12)	(0.12)	(1.60)	(10.53)	(2.33)	(3.51)
Observations	110	111	111	332	101	105	108	314
R-squared	0.24	0.02	0.14	0.06	0.17	0.02	0.08	0.04

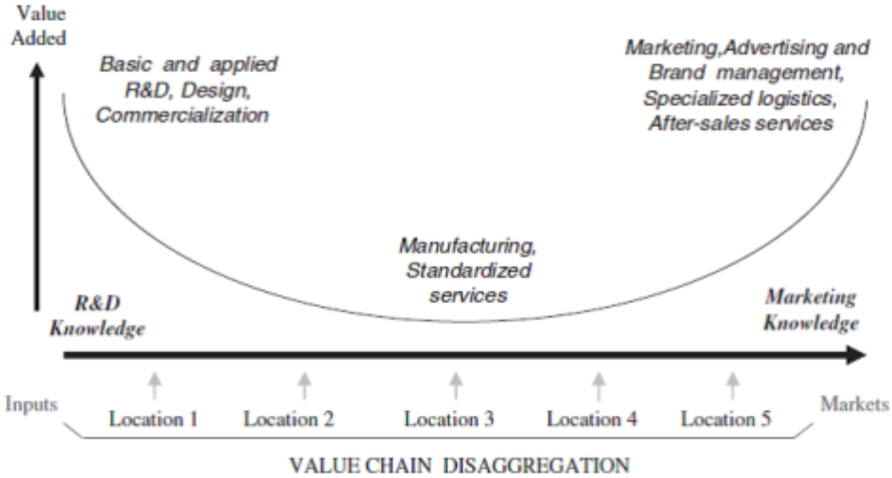
Notes: Robust standard errors are reported. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Table 5 Augmented Model: K/L <1

	Upstreamness		Profit Share		Q/L	
	(1)	(2)	(3)	(4)	(5)	(6)
K/L	1.91***	1.92***	0.67***	0.68***	11.39*	12.56*
	(0.23)	(0.24)	(0.18)	(0.19)	(6.33)	(6.65)
$(K/L)^2$			-0.69***	-0.70***	-10.02	-11.90
			(0.19)	(0.20)	(7.00)	(7.39)
US industry controls						
Assets	0.02	0.06	-0.00	0.01	-0.15	-0.11
	(0.03)	(0.04)	(0.00)	(0.01)	(0.20)	(0.15)
Advertising	-0.33***	-0.23***	0.00	0.00	0.21	0.13
	(0.07)	(0.07)	(0.01)	(0.01)	(0.19)	(0.12)
R&D	0.13**	0.09	0.01*	0.01	-0.06	0.01
	(0.06)	(0.06)	(0.01)	(0.01)	(0.08)	(0.08)
Trade protection measures						
Nontariff		1.11		-0.21**		-2.82*
barriers		(0.68)		(0.08)		(1.66)
FDI prohibited		2.33**		-0.03		-3.99*
		(0.90)		(0.15)		(2.36)
FDI restricted		0.38		-0.03		2.57**
		(0.29)		(0.04)		(1.29)
applied output		0.22*		-0.06**		0.30
tariff		(0.12)		(0.02)		(0.36)
applied input		-0.34		0.01		-3.24*
tariff		(0.37)		(0.06)		(1.95)
max output		-0.24**		0.06**		-0.17
tariff		(0.11)		(0.02)		(0.31)
max input		0.32		-0.02		2.83
tariff		(0.33)		(0.05)		(1.75)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	314	314	314	314	314	314
R-squared	0.25	0.28	0.11	0.14	0.04	0.07

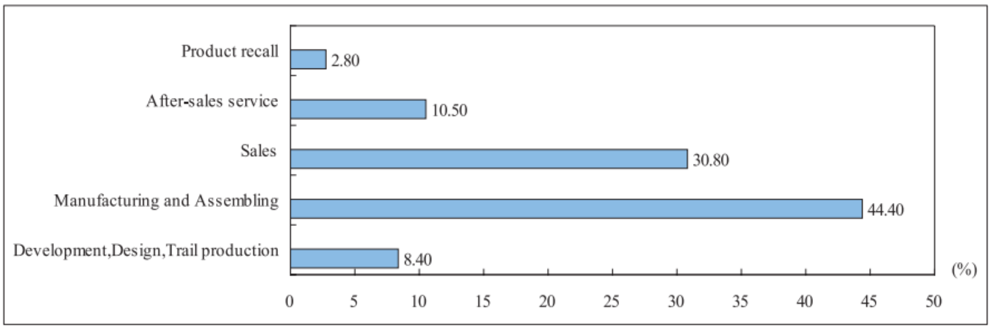
Notes: Robust standard errors are reported. *** Significant at 1%, ** significant at 5%, * significant at 10%.

Figure 1. Firm-level Smile Curve



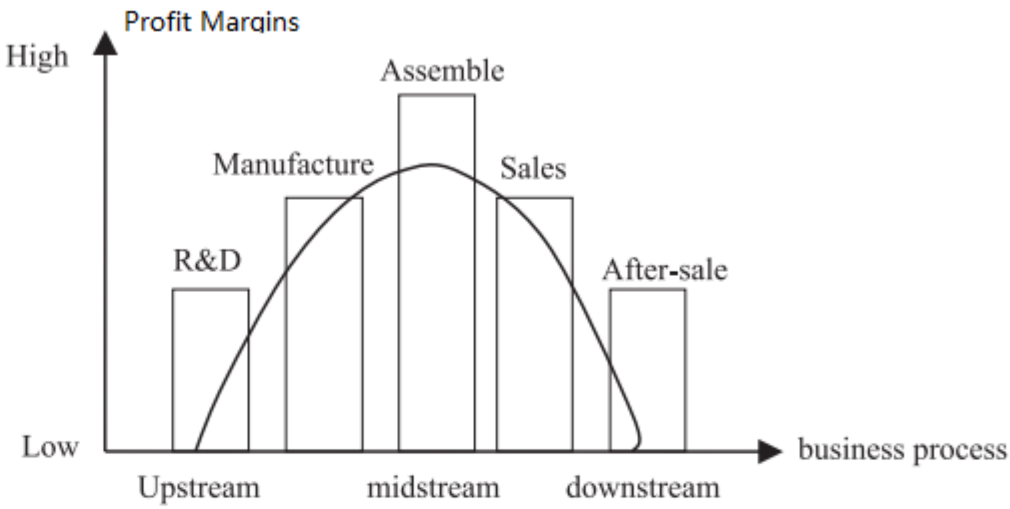
Source: Smiling Curve of value creation (Mudambi, 2007)

Figure 2. Percentage of Profit Margins distribution along Japanese manufacturing industry chains



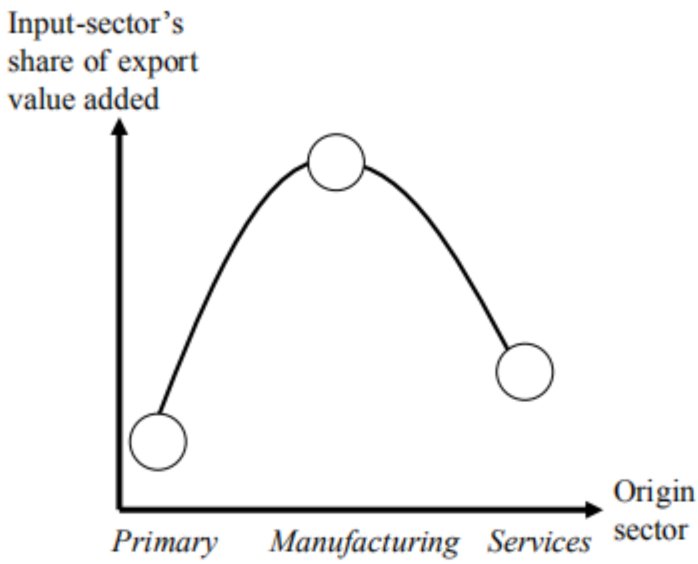
Source: White Paper on Manufacturing Industries, Japanese Ministry of Economy, Trade and Industry

Figure 3. Inverted U-shaped curve for Japanese manufacturing industries



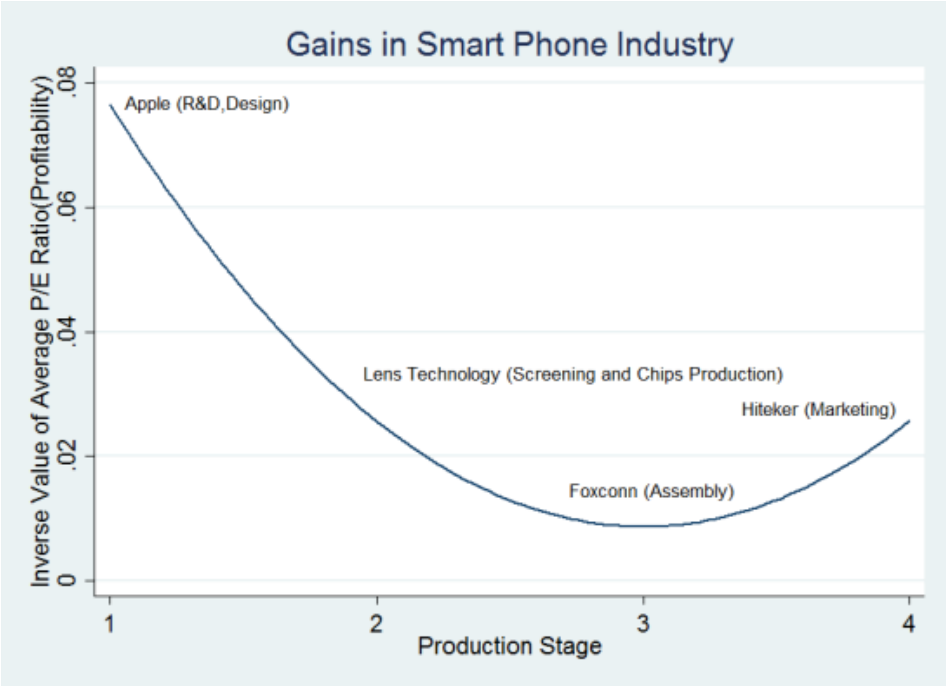
Source: Wang and Chen (2014)

Figure 4. Economy-wide division of the gains in Asian regions



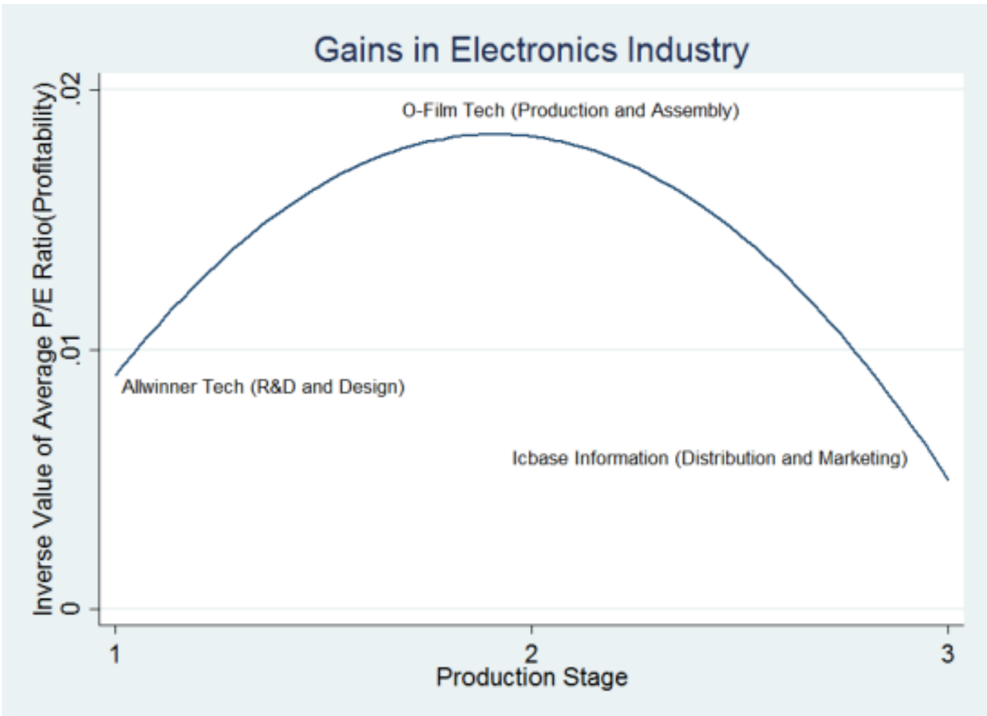
Source: Baldwin.et.al(2014)

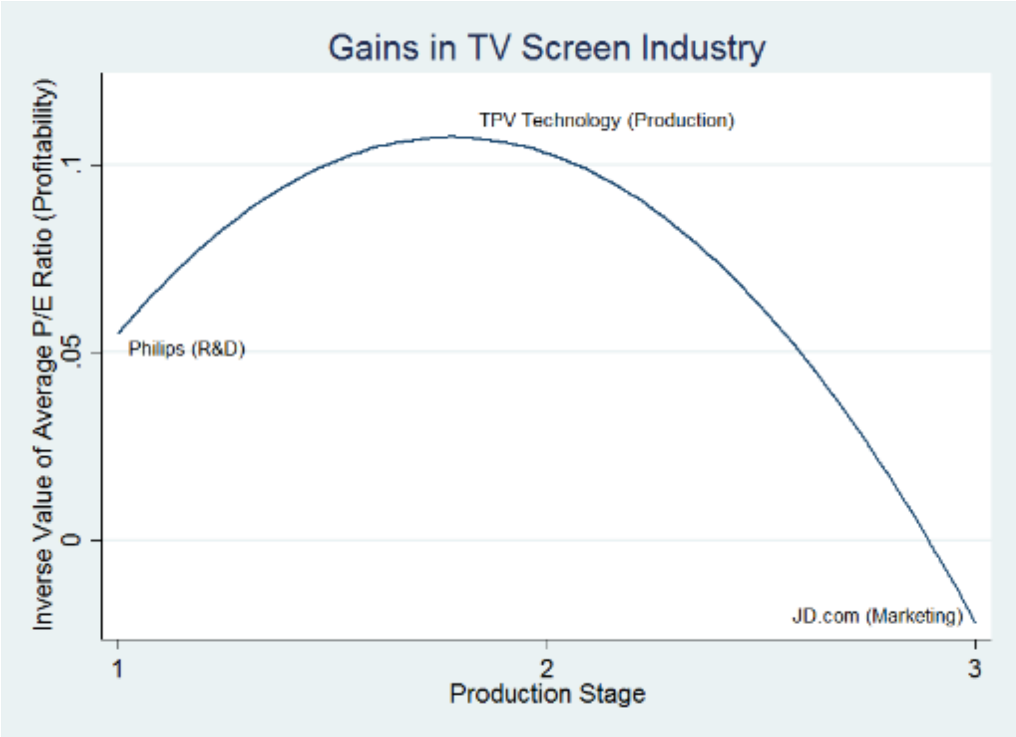
Figure 5.The dynamics of profit sharing along iPhone industry chain

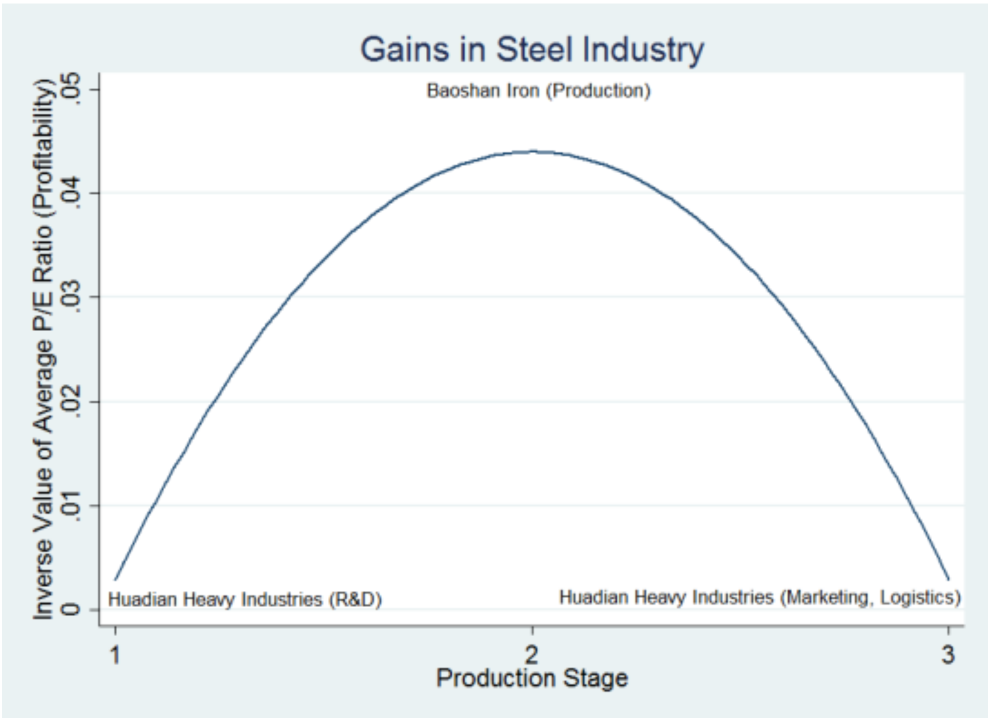


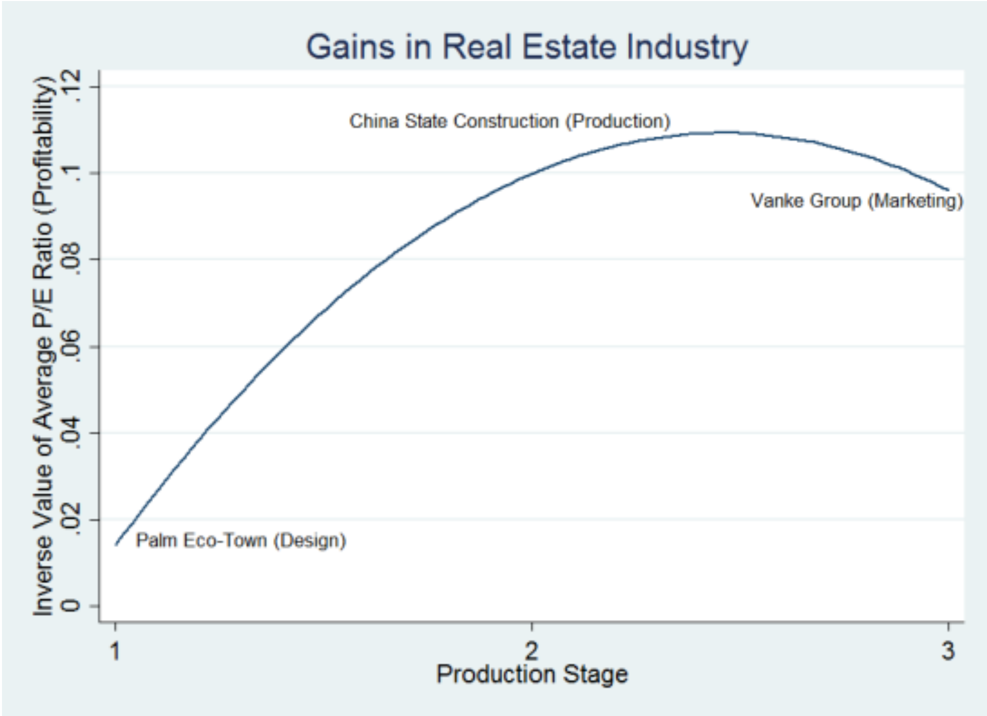
Source: Based on the authors' own calculations from Wind Information Database

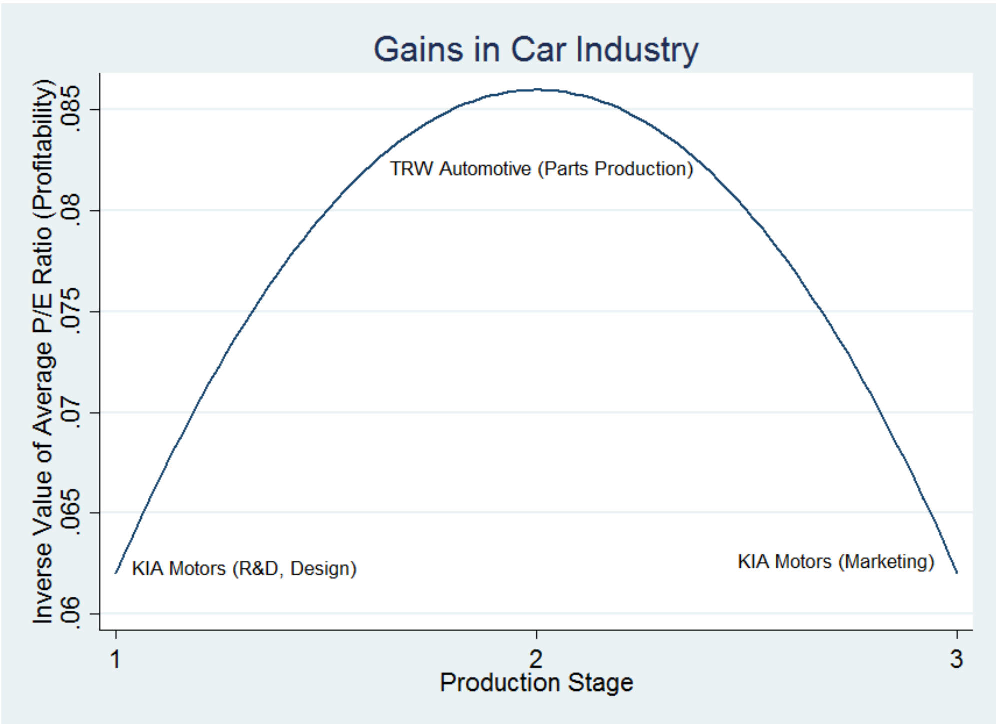
Figure 6. The dynamics of profit sharing along 5 Chinese industry chains




Gains in TV Screen Industry
TPV Technology (Production)
Philips (R&D)
JD.com (Marketing)
Inverse Value of Average P/E Ratio (Profitability)
0
.05
.1
1
2
3
Production Stage


Gains in Steel Industry
Baoshan Iron (Production)
Huadian Heavy Industries (R&D)
Huadian Heavy Industries (Marketing, Logistics)
Inverse Value of Average P/E Ratio (Profitability)
0
.01
.02
.03
.04
.05
1
2
3
Production Stage





Source: Based on the authors' own calculations from Chinese Industrial Enterprises, Chinese 2017 Statistical Yearbook.

Figure 7 Upstreamness and K/L Ratio

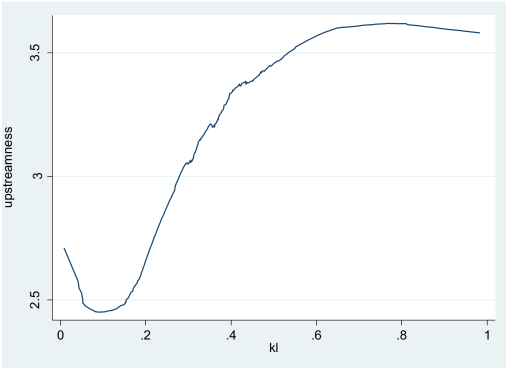


Figure 8 Profit Share and K/L Ra

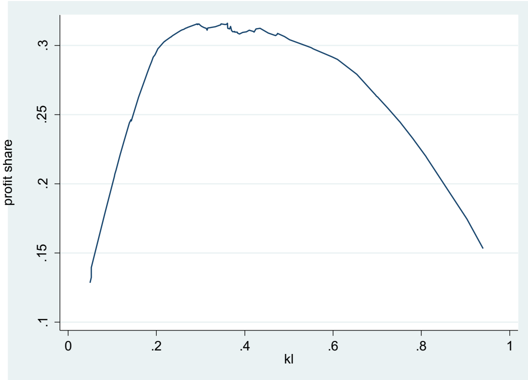


Figure 9 Q/L and K/L Ratio