A bilateral monopoly model of profit sharing along global supply chains[*]

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Abstract

This paper investigates the firm-level division of the gains in the global supply chain and provides a new theoretical framework to explain how gains are divided among firms and interdependent nations within the chain. It constructs an economic model using a bilateral monopoly market structure to analyse how the average profitability varies with the stages in the chain. By introducing a vertical restraint known as quantity fixing, the double marginalization problem arising as a result of bilateral monopoly can be resolved. It demonstrates joint-profit maximizing contracts emerge under quantity fixing parameters whereby the Assembly and downstream retailer eliminate the incentives for vertical integration.

This paper also shows the downstream retailer is more profitable than the upstream retailer if (and only if) both the capability and cost effect of Retailer dominates the two counterpart effects of Manufacturer. For the dominance of capability effect, the retailer must have lower monoposonist market power in the intermediate inputs market than in the final goods market where it acts as a monopolist. As a result, it could extract more surplus from consumers rather than Manufacturer. In terms of cost effect, the factor endowment structure differentials are important to the model. The labour intensive nature of the Manufacturer would lead it to the lower average product of labour, generating a lower level of profitability compared with upstream Retailer which is more capital intensive with higher average labour productivity. Extend it to a quantitative framework, the theories generated by this paper are broadly consistent with the data.

Keywords: global supply chain, bilateral contracting choices, quantity fixing, bilateral monopoly, average profitability, capability effect, cost effect

1 Introduction

Since the 1980s, there has been a fragmentation of production across the globe which Baldwin refers to as the "unbundling" of production. (Baldwin, 2012).[4] Although some of the current sequential production literature assumes perfect competition, monopolistic competition or oligopolistic competition in each sequential stage of the chain (Costinot et al, 2013; Ju and Su, 2013), this is far from what have been observed in reality.

For instance, Stuckey & White (1993) argued that due to the site specificity, technical specificity and human capital specificity, it is very likely that the bilateral monopoly market structure may emerge. The industries like mining, ready-mix concrete and auto assembly all operate as bilateral monopolies. At each production stage in the chain, there is an exclusive relationship between the upstream and downstream firm, where each firm monopolizes the production stage they specialize in. The most illustrative example is the Apple's supply chain where the firm monopolizes the upstream R&D stage and downstream Marketing stage whereas the Foxconn monopolizes the Assembly stage in the middle of the supply chain. (Chan, Pun and Selden, 2013). For the purposes of this paper we define the Retailer as a more general term which includes different sales activities after a product is finished assembly; these activities include advertising, distribution, after-sales service, logistics and so on.

[4] The separation of product production into a series of component stages has been widely used as a division of labour to enhance the production efficiency since the 18thcentury. Economist Adam Smith first elucidated how division of labour within a factory could save the production time as well as the cost: however, at the time, there was no such separation of product production into various working procedures across through different countries.

This paper develops a theoretical model under a bilateral monopoly framework to derive how and under what conditions the gains from global trade are unevenly distributed. It assumes a bilateral monopoly market structure in which there is only one-buyer and one-seller transactional relationship along the chain. This inevitably leads to problems of double marginalization in which the ex-post joint-profits of all firms producing along the chain could not be maximized.

In order to resolve this problem, we adopt the quantity fixing vertical restraint method to eliminate the double marginalization. As a vertical restraint, quantity fixing is equivalent to resale price maintenance. As argued by P. Rey and T. Verge (2005), such equivalence would hold as long as demand is known and depends only on the final price. In our paper, the final demand for the finished products is dependent upon the final prices, so quantity fixing would have the same functions as resale price maintenance does.[5]

There are two types of quantity fixing. (P.Ray and T.Verge,2005) One of them is called 'quantity forcing' which specifies a minimum quota imposed by one of the vertically-linked firms in the supply chain. The other one is called 'quantity rationing' which it specifies the maximum level of quota imposed by one of the firms in the chain. In our paper, it would be seen later in the paper that the general theoretical results would always hold regardless of which type of quantity fix that ought to be adopted as long as the fixed amount of quantity contract is offered by upstream manufacturer. In this paper, we fix the specified quantity, of which its level is between

[5] According to P.Ray and T.Verge(2005), the equivalence between resale price maintenance and fixing quantity would vanish when the retailer could buy from other manufacturer. Since in our paper, we argue there are exclusive dealings between manufacturer and retailer, so such equivalence would not break down in our case.

the forcing quantity and rationing quantity.

There are two reasons of choosing the quantity level that is between the minimum and maximum quantity. On the one hand, as T.Verge(2001) demonstrated, if the manufacturer offers more restrictive contract such as quantity forcing contracts, the retailer could no longer increase the quantity of its sold product if dealing exclusively with this product assembled by upstream manufacturer and the rent therefore left to be manufacturer would be smaller. In this case, it is worth for upstream manufacture to specify the minimum level of quantity. On the other hand, the specification of maximum level of quantity would be also sufficed. This is because manufacturers still need to leave a positive rent to the retailers and this rent still increases with the quantity supplied and consequently the manufactures would still distort the quantities they supplied and thus did not manage to maximize the joint-profits.

Furthermore, this fixed quantity must be at the level at which a vertically integrated firm would optimally set, the incentives for firms to vertically integrate would be eliminated in this case. Since this fixed quantity level is set by manufacturer, the optimal level of quantity set by the manufacturer is thus tantamount to the quantity level determined by the vertically-integrated firm.

This paper also sheds new light on the micro-foundation of how gains are divided among interdependent nations in global supply chain. Recent trade literature on the divisions of gains in global trade has been concentrated on the income distribution of the chain at the country level without the concrete firm-level analysis. (Costinot and

Fogel, 2010; Costinot et al, 2013; Basco and Mestieri, 2014; Verhoogen, 2008)

Generally, this literature has demonstrated income benefits for countries who participate in trade are unevenly distributed due to differences in countries' productivities, exports mix, quality upgrading process and so on;[6] however, this paper argues such an uneven distribution of gains in global trade can be attributed to firm-level reasons such as heterogeneity in market power between the intermediate goods and final goods market as well as the labour productivity differentials among different production stages in the chain. Firm-level analysis is particularly advantageous here as most of the country level trade is intra-industry trade or inter-industry trade, allowing this paper to provide a more unified framework than previous ones.[7]

Whereas most of the current trade papers focus on the consumption side gains within firms' vertical networks (Bernard and Dhingra, 2015; Fally and Hillberry, 2014; Ju and Su,2013), this paper provides a unified framework in which both the consumption side gains are measured by firms' capability effect (market power in the final good and intermediate good markets) and production side gains are measured by firms' cost effect (labor productivity and factor endowment structure).

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[6] Basco and Mestieri (2014) found a convex relationship, the "Lorenz curve," between world income distribution and the countries specializing at the intermediated production under the settings of heterogeneous productivity. Similarly, Sutton and Trefler link the wealth of a nation to its quality upgrading process of the exported goods. They argue a comparative advantage exists with respect to the quality of goods as well as the coexistence between high quality producers and low quality producers induced by the imperfect competition; an inverted U-shaped relationship between countries' GDP per capita and their exports mix emerges.

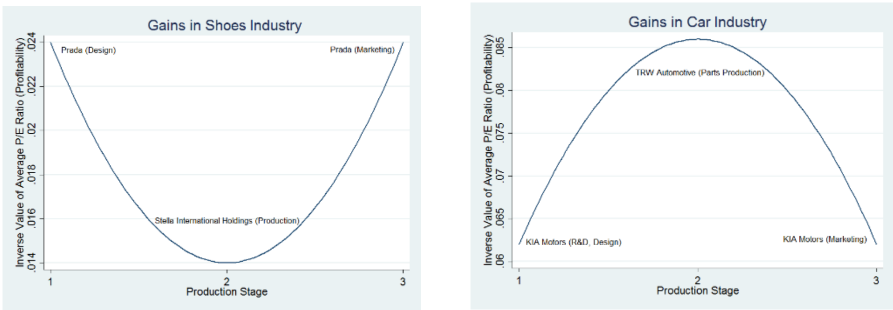
[7] Lu(2004) and Ishii and Kei-Mu Yi(1997) explain there are two types of specialization in the trade literature, "horizontal specialization" where specialization is operated among different countries producing different final goods and services; and "vertical specialization" where companies control their entire supply chain. This paper focuses on vertical specialization. For the further details of the difference between horizontal specialization and vertical specialization, consult these relevant papers.

2 Empirical Motivation

The principles of comparative advantage derived from Classical H-O trade model indicate that once developing economy firms (with an abundance of unskilled labors and the scarcity of capital) become global trade partners with firms from advanced economies (with an abundance of skilled labors as well as capital), there will be a rise in demand for unskilled labors; thus causing a cross-country convergence in wages. However, whether the convergence effect exists at the firm-level especially under the context of global supply chain still remains unanswered in both the empirical and theoretical literature. H Shen Jim, X.Liu and K.Deng (2016) empirically show upstream Retailers in advanced economies are not necessarily more profitable than Chinese midstream Manufacturers. Figure 1 below shows how the gains are unevenly distributed between Chinese manufacturers and Retailers from advanced economies in both the shoes and car industry production chains.

Figure 1: Divisions of the gains in Chinese shoes and cars supply chains[8]

[8] The vertical axis of these two graphs measure the profitability of firms locating at different stages in the chains. Shen, Liu and Deng (2016) use the inverse value of P-E ratio to be the proxy variable for profitability. The x-axis is the production stage ranging from R&D, Assembly and finally to Marketing stage. The part of the above two graphs we are interested in is just the Assembly stage and Marketing stage. The study by Sutton and Trefler (2016) provides a very strong country-level empirical motivation for this paper. They detect the channel through which quality of goods exported by advanced economies is higher than that of firms in emerging economies (quality effect), while GDP per worker is also higher for firms specializing at these economies (wage effect). Overall, the wage effect may dominate the quality effect, thus generating the low exports values as well as declining profitability of firms in these economies. Hence, an inverted U-shaped relationship between countries' GDP per capita and their exports mix emerges.



Sources: H.Shen Jim, X.Liu and Kent Deng (2016)

From the above figure 1, it shows that gains in Shoes Industry chains exhibits the U-shaped curve whereas the distribution of gains in Car Industry chain depict inverted U-shaped curve. For labor-intensive shoes industry, downstream retailer is more profitable than midstream Assembly whereas for capital-intensive car industry, the opposite is true. In this paper, we will argue that such factor endowment differentials across industries are the crucial factor to understand different patterns of division of the gains in the global supply chains. Secondly, According to G.Gereffi (1999), there are two types of global supply chains. One is buyer-driven global supply chain whereas the other one is producer-driven global supply chain. The former one , as argued by him, has more labour intensive firms in the middle (assembly) and the lead firms are downstream retailers whose capital-intensities are higher and their technological level are more advanced than other firms locating in the other positions in the chains. The producer-driven chains are characterized by having the firms in the middle that are more capital-intensive and higher level of technology compared with the downstream retailers. Thus, one could argue that the variability of capital-intensity across firms in the chains is also crucial for us to understand the division of the gains in global supply chains. In addition, having higher technology level, which generates the higher market power and entry barriers is also another important factors that shape the division of the gains in global supply chains.

The rest of the paper is organized as follows. Section III provides the basic explanation for the theoretical model; which is then explained and solved in Section IV. The final section provides the conclusion and some notes on possible future research.

3. Model

3.1 Supply Chain

Consider a global supply chain which consists of 2 (country) firms and where each (country) firm only specializes at one particular stage within the chain. Put another way, we exclude all situations where more than one firm specializing at a particular stage and where there is no competition among firms at a particular stage. This then leads to the one-to-one injective mapping relationship among countries, firms and stages.[9]

To produce the final good, there exists a finite sequence of stages, denoted by S=$\{s_1, s_2\}$ where $s_i \in S$, $1 \leq i \leq 2$. The *stage i* is denoted by s_i. s_i here is not a variable but rather the discontinuity points indicating which stage that the firms in the supply chains locate at. This is to say, the function is not differentiable at s_i. Now the notation i is used such that the whole global supply chain could be split into the 2 stages including both upstream (manufacturer) and downstream (retailer) as shown in the following:

[9] The model in this paper is in line with the hierarchy assignment model developed by Lucas (1978), Kremer (1993), Garicano and Rossi-Hansberg (2004, 2006), only we incorporate their framework into the context of sequential production.

$$\begin{cases} Upstream\ manufacturer\ if\ i = 1 \\ Downstream\ retailer\ if\ i = 2 \end{cases}$$

3.2 Contracting choices (Quantity fixing)

By assuming bilateral and joint-profit maximizing contracts, we eliminate the incentives for firms to vertically integrate in the chains by the means of quantity fixing. In line with Bernard and Dhingra (2015), the model offered by this paper embeds the bilateral and joint-contracting choices developed by Hart and Tirole (1990) into the sequential production framework to resolve the problems of double marginalization and lower joint-profitability caused by the bilateral monopoly market structure of the chain.

This fixing quantity is imposed at the level is tantamount to which a vertically-integrated firm in the chain would set to maximize the joint-profits. Through the quantity fixing, each of these 2 firms could not reduce their respective output for the purpose of marginalizing. This leads to the first assumption for this model:

Assumption 1: The output in all stages is equal $q(s_1) = q(s_2) = q^*$ [10] where $q(s_1)_{min} \leq q^* \leq q(s_1)_{max}$ where $q(s_1)_{min}$ is the quantity forcing specified by the manufacturer whereas $q(s_1)_{max}$ is the specified quantity rationing.[11]

3.3 Consumers

We follow the P.Antras and D. Chor's approach in 2013 to characterize the

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[10] This condition for quantity also implies that we do not consider the 'mistake rate' (error rate) during the process of sequential production. Each firm in the chain, has a fixed proportional output at the inter-stage level. This implies the supply function for each firm at each stage is fixed. The fixed proportion of output at each sequential stage is also an assumption initially used by Stigler (1951) to study the evolution of production over the life cycle of an industry.

[11] In this paper, there exists a level of fixed quantity set by upstream manufacturer and this quantity must be bought by downstream retailer.

preference of consumers. The final good is a differentiated variety from the perspective of the individual consumer and belongs to an industry where firms produce a continuum of goods. The following utility function represents consumers' preference, which features a constant of substitution across these varieties:

$$U = (\int_{\omega \in \Omega} q_2(\omega)^{\rho} d\,\omega)^{\frac{1}{\rho}}$$

Where $\rho \in (0,1), q_3(\omega)$ is the quality-adjusted output of variety ω and Ω is the set of varieties consumed.

Thus, the monopolistic downstream retailer producing variety ω will face a demand function in the final goods market as follows:

$q_2(\omega) = Ap(\omega)^{-\frac{1}{1-\rho}}$ where A>0 indicating the industry demand shifter, which is exogenous.

Denote $\epsilon_2 = \frac{1}{1-\rho}$ Where ϵ_2 be the price elasticity of demand in the final good market. A is a positive parameter. It is obvious to see that the demand function faced by the retailer in the final goods market is in the multiplicative form, which treats the market power that possessed by downstream firm as the vital part in our current consumer side of the story.

3.4 Production

Due to the indeterminacy of the prices charged by the vertically linked firms under the setting of bilateral monopolistic structure, the bargaining power of each firm has to be introduced to determine the final negotiated price among vertically-linked firms.

We denote $\lambda_i = \{\lambda_1, \lambda_2\}$ as a bounded set of the distribution of bargaining power of each of these 2 firms in the chain. Where $\lambda_1 + \lambda_2 = 1$

Moreover, in this paper, firms locating at sequential of stages with distinct types (different productivity measured by different firms' cost capacity) will have different measure of desirable physical characteristics of goods (such as quality). Such distinct characteristics are achieved through different level of enhanced advertising expenditure (Sutton, 1991). This means firms producing more knowledge-intensive goods such as those involved in the Marketing stage would expend more money in advertising, whereas those producing less knowledge-intensive goods such as firms locating in the assembly sector would spend less money advertising. Sequence of stages in the chain are characterized by distinct quality level of goods being provided. Quality upgrading requires a different level of sunk cost for firms invest in order to maintain their viability in the chain. Such endogenous sunk cost could be denoted as $F(s_i)$, where *i =1,2*

The term $F(s_i)$ represents the endogenous sunk cost for the firm to be viable at stage *i*. This paper shows firms specializing at more knowledge-intensive stages tend to spend more money on advertising, thus generating higher level of endogenous sunk cost whereas firms specializing at less knowledge-intensive stages such as Assembly stage would spend much less money on the advertising which leads to a lower level of endogenous sunk cost. Hence, it leads to our final assumption of this paper:

Assumption 2. (Endogenous sunk cost assumption)

$$F(s_2) - F(s_1) > \frac{1}{2}$$

For a given chain, it is possible to formulate the equilibrium as 2 equilibrium profit functions for each of vertically linked firm involved in the chain:

$$\begin{cases} \pi_{assembly} = p^*(s_1, q^*)q^* - C(s_1, q^*) \\ \pi_{marketing} = p_m(q^*)q^* - p^*(s_1, q^*)q^* - C(s_2, q^*) \end{cases}$$

Where $C(s_i, q^*)$ is the total cost of firm specializing at stage *i*. The demand function for the intermediate input market is represented by $p(s_1, q)$. $p^*(s_1, q)$ is the price between upstream Manufacturer and downstream retailer after negotiation. $p_m(q^*)$ is the price charged to consumers in the final good market.

4. Solution

4.1 Assembly stage

4.11 Cost Minimization

We define the constrained cost minimization problem for the manufacturer as the following:

$$C(w, r, s_1) = \underbrace{Min}_{L(s_1), K(s_1)} \quad w(s_1)L(s_1) + rK(s_1) + F(s_1) \tag{1}$$

s.t $q_1 = L(s_1)^{\alpha(s_1)} K(s_1)^{\beta(s_1)}$ where production function is in Cobb-Douglas type.

We construct the Lagrangian function as the following:

$$\phi_r(w, r, q, s_1) = w(s_1)L(s_1) + rK(s_1) + F(s_1) - \lambda_r\left[L^{\alpha(s_1)} K^{\beta(s_1)} - q_1\right] \tag{2}$$

Take the derivative (2) with respect to $L(s_1)$, $K(s_1)$ and λ_r respectively and let them equal to 0, we obtain the following first order condition:

$$\begin{cases} w(s_1) = \lambda\alpha(s_1)L(s_1)^{\alpha(s_1)-1}K(s_1)^{\beta(s_1)} \\ r = \lambda\beta(s_1)K(s_1)^{\beta(s_1)-1}L(s_1)^{\alpha(s_1)} \\ q_1 = L(s_1)^{\alpha(s_1)}K(s_1)^{\beta(s_1)} \end{cases} \tag{3}$$

Divide first equation of the (3) by the second equation of the (2), the Lagrangian multiplier λ is cancelled to obtain the following relationship between capital input and labour input:

$$K(s_1) = \left[\frac{\beta(s_1)w(s_1)}{\alpha(s_1)r}\right] L(s_1) \quad (4)$$

Plug (4) into the production function which is the third equation of the (3), we obtain the conditional input demand for the labour for this Manufacturer:

$$L(s_1, q_1) = \left[\frac{\alpha(s_1)r}{\beta(s_1)w(s_1)}\right]^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} q_1^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \quad (5)$$

Similarly, we can obtain the conditional input demand for the capital for this Manufacturer:

$$\mathrm{K}\,(s_1, q_1) = \left[\frac{\beta(s_1)w(s_1)}{\alpha(s_1)r}\right]^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} q_1^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \quad (6)$$

So we obtain the minimized cost function for the Manufacturer in the supply chain:

$$\mathrm{C}(L(s_1, q_1), \mathrm{K}\,(s_1, q_1), s_1) =$$

$$w(s_1) \left[\frac{\alpha(s_1)r}{\beta(s_1)w(s_1)}\right]^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} q_1^{\frac{1}{\alpha(s_1)+\beta(s_1)}} + r\left[\frac{\beta(s_1)w(s_1)}{\alpha(s_1)r}\right]^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} q_1^{\frac{1}{\alpha(s_1)+\beta(s_1)}} + \mathrm{F}(s_1)$$

(7)

which can be further reduced to the following form:

$$\mathrm{C}(L(s_1, q_1), \mathrm{K}\,(s_1, q_1), s_1) =$$

$$q_1^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]\left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} + \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] + \mathrm{F}(s_1)$$

(8)

Now we could derive the marginal cost curve for the Manufacturer:

MC

$(s_1, q_1) = \frac{1}{\alpha(s_1)+\beta(s_1)}\ q_1^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} + \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]$

(9)

4.12 Profit Maximization

We are now going to state the profit maximization problem for the Manufacturer by using the derived cost function above to find profit maximizing equilibrium price set by the Manufacturer.

$\underbrace{Max}_{q_1}\ \pi_{Assembly}(w(s_1), r, q_1, s_1) = p(s_1, q_1)q_1 - \mathrm{C}(L(s_1, q_1), \mathrm{K}\,(s_1, q_1), s_1) - \mathrm{F}(s_1) =$

$p(s_1, q_1)q_1 - q_1^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} + \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] - \mathrm{F}(s_1)$

(10)

Take the derivative of (10) with respect to q_1, we obtain the following:

$$p_a(s_1, q_1) + \frac{\partial p(s_1,q)}{\partial q}.\, q_1 = \frac{1}{\alpha(s_1)+\beta(s_1)}\ q_1^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} + \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \quad (11)$$

Factoring out the $p_{\mathrm{a}}(s_1, q_1)$ on the left side, we obtain profit maximizing equilibrium price set by the Manufacturer in the chain:

$$p_a(s_1, q) = \frac{1}{\alpha(s_1)+\beta(s_1)}\ q_1^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} + \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \left[\frac{\epsilon_1}{\epsilon_1 - 1}\right] \quad (12)$$

Where ϵ_1 is the price elasticity of inputs market supply at Assembly stage and this parameter measures the upstream retailer's monosoponist market power.[12]

Let q_1=q^* be the fixing quantity under the bilateral contracts between the retailer and Manufacturer, then profit maximizing price level set by the Manufacturer at the fixing quantity q^* according to the bilateral contracts is:

$$p_a(s_1,q^*)=\frac{1}{\alpha(s_1)+\beta(s_1)}(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]\left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}+\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]\left[\frac{\epsilon_1}{\epsilon_1-1}\right] \quad (13)$$

Lemma 1 (second order condition check) *Under bilateral Monopoly, the upstream manufacturer would maximize its profits at the equilibrium price level implied by (13) if and only if it produces at the production level which exhibits increasing return of scale.* $(\alpha(s_1)+\beta(s_1)>1)$

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

5.1 Marketing Stage

Nonetheless, the Manufacturer cannot obtain above profit-maximizing position implied by (13) because it does not sell in a market with many buyers and each of

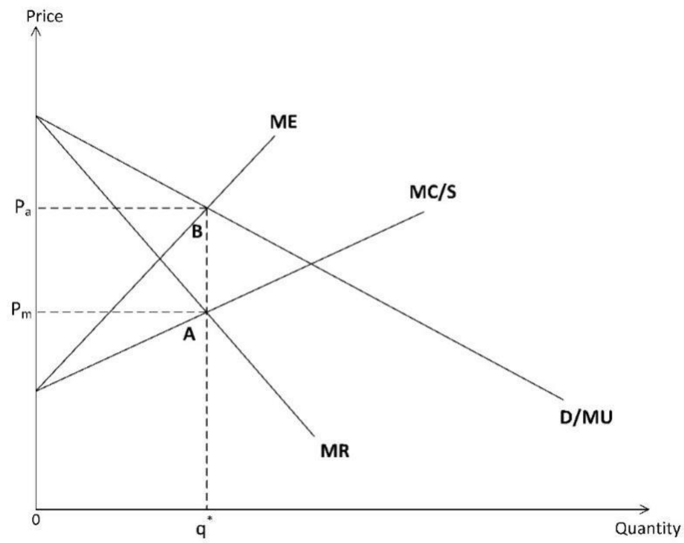
12 In modern I-O theory the monopolistic seller does not have control of the supply curve. However, this is not the case when it is applied into the context of bilateral monopoly when there exists an indeterminacy of the finally agreed prices between the monoposonist and the monopolist. This is because the price set by the monoposonist, which is the lower limit of the negotiated price range between the monoposonist and monopolist, can only be achieved if and only if he could force the monopolist seller to act as a perfect competitor. The same logic holds for the price setting authority of monopolistic sellers over the monoposonist buyer. Hence, as it is assumed that the monopolist seller behaves as if his prices were determined by forces from the downstream monoposonist. Formula (12) could still be considered the supply curve of this monopolistic seller in the input markets. Since this monopolistic seller acts as the suppliers of input factors and the degree of monoposonist market power is determined by the extent to which this monopolistic seller could freely charge his factor prices. So ϵ_1 could be treated as a measure of monoposonist market power.

buyers would be incapable of affecting the prices by his purchases. The Manufacturer is selling to a single retailer who can obviously affect the market price by this input purchasing decisions.

Hence, as the monopsonist Retailer is aware of its market power and he will set price terms upon the Manufacturer. The increase in the expenditure of the Retailer resulting from the rises in his input purchasing is shown by the curve ME in figure 2. In other words, curve ME is the marginal cost of inputs for the monopsonist Retailer.

Thus in order to maximise its profit, the Retailer will purchase additional units of X until his marginal expenditure is equal to his price, which is determined by the demand curve D as shown in the figure 2. The price charged by the downstream monoposonist Retailer could be found from the supply curve (marginal cost curve) of the monopolistic Manufacturer which is tantamount to the average expenditure curve of the downstream retailer implied by the point A.

Figure 2 Bilateral Monopoly under quantity fixing in the supply chain



The equilibrium point of the Retailer is implied by point A in the figure 2 and its price is implied by p_m. Similarly, the equilibrium point of the Manufacturer is implied by point B where the demand curve of Manufacturer and its marginal expenditure curve intersect with each other. Its setting price is indicated by p_a.[13]

Hence we plug the fixing quantity q^* into the marginal cost curve faced by the Manufacturer indicated by (9) to obtain the explicit expression for the price level charged by the downstream retailer upon the Manufacturer:

$$P_m = \mathrm{MC}\,(s_1, q^*) = \frac{1}{\alpha(s_1)+\beta(s_1)}\,(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]\left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} + \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \quad (14)$$

In order to resolve the indeterminacy of the prices both agreed by the Manufacturer and the Retailer, the bargaining power is introduced here to capture what is the final negotiated price level agreed between Retailer and Manufacturer. It is asserted the negotiated price level in relation to the bargaining power of each side of the market is linear:

$p^*(s_1, q^*) = \lambda_1 p_a(s_1, q^*) + \lambda_2 P_m(s_1, q^*)$ [14] (***See footnote for the proof of this linearity***)

(15)

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[13] The demand curve could be treated as the average revenue curve of the manufactureing firm which measures its total value of marginal product.

[14] The proof of the liner relationship between the final negotiated price level and two different price levels respectively charged by the monopolist and the monoposonist is as follows: start from the method proposed by Glen Wely (2012), suppose if the upstream manufacturer sells his one unit of intermediate inputs at the negotiated price p'. Given that the disagreement payoffs for both Retailer and Manufacturing firm is 0, then the payoff function for the downstream retailer is $U_m(p' - p_m) = (p' - p_m)^{\lambda_1}$ Similarly, $U_a(p_a - p') = (p_a - p')^{\lambda_2}$ is the payoff function for the upstream manufacturer. p_m is the willingness to pay for the monosoponist retailer whereas p_a is the price charged by the monopolist Assembly firm. Also, $\lambda_1 + \lambda_2 = 1$. The " Nash product" therefore is $\underbrace{Max}_{p'}\ (p' - p_m)^{\lambda_1}(p_a - p')^{\lambda_2}$ s.t $p_m \leq p' \leq p_a$ We could just maximize the " Nash product" without constraint if the solution to this product satisfies the constraint. So differentiate the objective function wrt p' and setting equal to 0 gives $\lambda_1(p' - p_m)^{\lambda_1 - 1}(p_a - p')^{\lambda_2} = \lambda_2(p' - p_m)^{\lambda_1}(p_a - p')^{\lambda_2 - 1}$ Dividing both sides of this first

Where $\lambda_1 + \lambda_2 = 1$

λ_1 is the bargaining power of the Manufactuer and λ_2 is the bargaining power of the Retailer

Denote $\theta_1 = \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]$, $\theta_2 = \left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} + \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]$,

We obtain the explicit expression for the negotiated price level agreed by the Manufacturer and Retailer:

$$p^*(s_1, q^*) = \left\{\frac{\lambda_1}{\alpha(s_1)+\beta(s_1)}(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2] \times \left[\frac{\epsilon_1}{\epsilon_1 - 1}\right]\right\} + \left\{\frac{\lambda_2}{\alpha(s_1)+\beta(s_1)}(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2]\right\} \quad (16)$$

5.11 Cost Minimization

In order to get the explicit expression for the equilibrium price set by the Retailer towards consumers in the final market, we consider the following constrained cost minimization problem:

$$\underbrace{Min}_{L(s_2),K(s_2)} \quad C(w(s_2), r, s_2) = w(s_2)L(s_2) + rK(s_2) + F(s_2) \quad (17)$$

s.t $q_2 = L(s_2)^{\alpha(s_2)} K(s_2)^{\beta(s_2)}$

Here we assume labour market is perfectly competitive and the labor supply is perfectly elastic. So the monopsonist is non-discriminating and it only sets the single level of wage $w(s_2)$ to all workers.

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order condition by $(p' - p_m)^{\lambda_1 - 1}(p_a - p')^{\lambda_2 - 1}$ gives $\lambda_1(p_a - p') = \lambda_2(p' - p_m)$. Rearranging this expression and solving for p' leads to $p' = \frac{\lambda_1}{\lambda_1+\lambda_2} p_a + \frac{\lambda_2}{\lambda_1+\lambda_2} p_m$. This implies that $p' = \lambda_1 p_a + \lambda_2 p_m$.

We can also construct the following Lagrangian function to solve the constrained optimization problem shown by (17):

$$\phi_a(\text{w}, \text{r}, q_2, s_s) = w(s_2)L(s_2) + \text{rK}(s_2) + \text{F}(s_2) - \lambda_a\left[L(s_2)^{\alpha(s_2)}K(s_2)^{\beta(s_2)} - q_2\right]$$

(18)

Similar to the derivation of the cost minimized conditional input demand for labor and capital for the Manufacturer, it is possible to obtain the following expression of the cost minimized conditional input demand for labor and capital for the downstream retailer:

$$\begin{cases} L^*(s_2, q_2) = \left[\frac{\alpha(s_2)r}{\beta(2)w(s_2)}\right]^{\frac{\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} q_2^{\frac{1}{\alpha(s_2)+\beta(s_2)}} \\ K^*(s_2, q_2) = \left[\frac{\beta(s_2)w(s_2)}{\alpha(s_2)r}\right]^{\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}} q_2^{\frac{1}{\alpha(s_2)+\beta(s_2)}} \end{cases}$$

Hence the minimized total cost function for the Retailer could be represented as the following:

$$C(L^*(s_2, q_2), K^*(s_2, q_2), s_2) = q_2^{\frac{1}{\alpha(s_2)+\beta(s_2)}}\left[w(s_2)^{\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}} r^{\frac{\beta(s_2)}{\alpha(s_2)+\beta(s_2)}}\right]\left[\left(\frac{\alpha(s_2)}{\beta(s_2)}\right)^{\frac{\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} + \left(\frac{\alpha(s_2)}{\beta(s_2)}\right)^{\frac{-\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}}\right] + \text{F}(s_2) \quad (19)$$

Denote $\theta_3 = \left[w(s_2)^{\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}} r^{\frac{\beta(s_2)}{\alpha(s_2)+\beta(s_2)}}\right]$, $\theta_4 = \left[\left(\frac{\alpha(s_2)}{\beta(s_2)}\right)^{\frac{\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} + \left(\frac{\alpha(s_2)}{\beta(s_2)}\right)^{\frac{-\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}}\right]$

So we have $C(L^*(s_2, q_2), K^*(s_2, q_2), s_2) = q_2^{\frac{1}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4 + \text{F}(s_2)$

(20)

Thus, the marginal cost curve for this retailer is:

$$\frac{\partial C(L^*(s_2,q_2),K^*\,(s_2,q_2),s_2)}{\partial q_2} = ME_m = MC_m = \frac{1}{\alpha(s_2)+\beta(s_2)} q_2^{\frac{1-\alpha(s_2)-\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4$$

(21)

5.12 Profit Maximization

The profit maximization problem for the Retailer can be determined by using the derived cost function implied by (20) to find its optimal price.

$$\underbrace{Max}_{q_2}\ \pi_{marketing}(w(s_2), r, q_2, s_2) = p_f(s_2, q_2)q_2\text{-}\ C(L^*(s_2, q_2), K^*\,(s_2, q_2), s_2) - \mathrm{F}(s_2) - p^*(s_1, q^*)q_2$$

(22)

Solve this by taking the derivative of (22) with respect to q_2 and let it equal to 0:

$$p_f(s_2, q_2) + \frac{\partial p(s_2,q_2)}{\partial q}.q_2 - \frac{1}{\alpha(s_2)+\beta(s_2)} q_2^{\frac{1-\alpha(s_2)-\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4 - \left\{\frac{\lambda_1}{\alpha(s_1)+\beta(s_1)}(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2] \times \left[\frac{\epsilon_1}{\epsilon_1-1}\right]\right\} - \left\{\frac{\lambda_2}{\alpha(s_1)+\beta(s_1)}\ (q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2]\right\} = 0$$

(23)

Factoring out the $p_f(s_2, q)$ on the left side, we obtain profit maximizing equilibrium price set by the retailer in the chain:

$$p_f(s_2, q_2) = \left\{\frac{1}{\alpha(s_2)+\beta(s_2)} q_2^{\frac{1-\alpha(s_2)-\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4 + \left\{\frac{\lambda_1}{\alpha(s_1)+\beta(s_1)}(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2] \times \left[\frac{\epsilon_1}{\epsilon_1-1}\right]\right\} + \left\{\frac{\lambda_2}{\alpha(s_1)+\beta(s_1)}\ (q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2]\right\}\right\} \times \left[\frac{\epsilon_2}{\epsilon_2-1}\right] \qquad (24)$$

Where ϵ_2 is the price elasticity of demand in the final market.

Hence at the fixing quantity q^*, retailer in the final good market has to charge the following equilibrium price towards the consumers:

$$p_f(s_2, q^*) = \left\{\frac{1}{\alpha(s_2)+\beta(s_2)}(q^*)^{\frac{1-\alpha(s_2)-\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4 + \left\{\frac{\lambda_1}{\alpha(s_1)+\beta(s_1)}(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2] \times \left[\frac{\epsilon_1}{\epsilon_1-1}\right]\right\} + \left\{\frac{\lambda_2}{\alpha(s_1)+\beta(s_1)}(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2]\right\}\right\} \times \left[\frac{\epsilon_2}{\epsilon_2-1}\right] \quad (25)$$

Lemma 2: (second order condition check) *Under bilateral monopoly, the downstream retailer would maximize its profits at the equilibrium price level implied by (25) if and only if it produces at the production level which exhibits either constant return of scale* $(\alpha(s_2) + \beta(s_2) = 1)$ *or increasing return of scale.* $(\alpha(s_2) + \beta(s_2) > 1)$.

For the proof of Lemma 2, please see Appendix B.

6. Simultaneous determination of fixing quantity contract along the chain

Under quantity fixing, a sales restriction imposed by the upstream Manufacturer exists among the firms in the chain. This is a level of sales quota q^* which all firms in the chain are contract. This satisfies the nature of joint-profits maximization according to the optimal quantity level set by a vertically integrated firm in the chain.

In order to obtain the expression for the ideal quantity fixing, we first identify the joint-profit maximizing problem faced by a vertically integrated firm in the chain:

$$Max \underbrace{\pi_{joint}}_{q} = \pi_{assembly} + \pi_{marketing} = p_f(q)q - C(s_1, q) - F_{assembly}(s_1) - C(s_2, q) - F_{marketing}(s_2) \quad (26)$$

Where q is the optimal level of fixing quantity set by the vertically integrated firm in the chain. This leads to the first proposition in this paper:

Proposition 1*: Under the bilateral and joint-profit maximizing contracting choices in which the quantity restrictions are imposed upon all the firms producing along the chain such that double marginalization problem could be avoided, the optimal fixing quantity contract*$[p^*(s_1, q^*), q^*]$*must satisfy the following closed-form solution when* $\alpha(s_2) + \beta(s_2) = 1$*:*[15]

$$\begin{cases} p^*(s_1, q^*) = \left\{ \left\{ \dfrac{A^{\frac{1}{\epsilon_2}} \left[E^{\frac{1}{x\epsilon_2}} \right] - \theta_3 \times \theta_4}{(\frac{\epsilon_2}{\epsilon_2 - 1})(\frac{\epsilon_1 - 1}{\epsilon_1})} \right\}^{\frac{\epsilon_2}{x\epsilon_2 + 1}} \left\{ \lambda_1 + \lambda_2 (\frac{\epsilon_1 - 1}{\epsilon_1}) \times \frac{1}{\theta_1} \times \frac{1}{\theta_2} \right\} \right\} \\ q^* = \left[\dfrac{\left\{ \dfrac{A^{\frac{1}{\epsilon_2}} \left[E^{\frac{1}{x\epsilon_2}} \right] - \theta_3 \times \theta_4}{(\frac{\epsilon_2}{\epsilon_2 - 1})(\frac{\epsilon_1 - 1}{\epsilon_1})} \right\}^{\frac{\epsilon_2}{x\epsilon_2 + 1}}}{\{E\}^{\frac{1}{x}}} \right] \end{cases}$$

Where E=$\left\{ \frac{1}{\alpha(s_1) + \beta(s_1)} \right\} \times \theta_1 \times \theta_2 \times \frac{\epsilon_1}{\epsilon_1 - 1}$ and x=$\frac{1 - \alpha(s_1) - \beta(s_1)}{\alpha(s_1) + \beta(s_1)}$

$$(A)^{\frac{1}{\epsilon_2}} (q^*)^{-\frac{1}{\epsilon_2}} == (\frac{\epsilon_2}{\epsilon_2 - 1}) \left\{ \left[\frac{1}{\alpha(s_1) + \beta(s_1)} (q^*)^{\frac{1 - \alpha(s_1) - \beta(s_1)}{\alpha(s_1) + \beta(s_1)}} \times \theta_1 \times \theta_2 \right] + \left[\frac{1}{\alpha(s_2) + \beta(s_2)} (q^*)^{\frac{1 - \alpha(s_2) - \beta(s_2)}{\alpha(s_2) + \beta(s_2)}} \times \theta_3 \times \theta_4 \right] \right\}$$

For the proof of Proposition 1, please see Appendix C.

7. Equilibrium profits

To derive under what condition the average profitability of Manufacturer is higher than that of downstream retailer or vice versa we need to identify the respective

[15] We only consider the case in which retailer exhibits the constant return of scale due to the possibilities of obtaining the closed-form solution for the fixing quantity contracting. It would not lose the generality of the conclusions drawn from the theoretical predictions from this paper if the case of increasing return of scale is excluded as constant return of scale condition has already ensured that the retailer is producing at the minimum average cost level.

equilibrium profits expression for the upstream firm and downstream one. For the upstream manufacturer, its equilibrium profits could be stated as the following:

$$\pi_{assembly} = p^*(s_1, q)q^* - C(s_1, q^*) =$$

$$\left\{\frac{\lambda_1}{\alpha(s_1)+\beta(s_1)}(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2] \times \left[\frac{\epsilon_1}{\epsilon_1 - 1}\right]\right\} + \left\{\frac{\lambda_2}{\alpha(s_1)+\beta(s_1)}(q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2]\right\} \times q^* -$$

$$(q^*)^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2] - \mathrm{F}(s_1)$$

(27)

(27) could be further reduced to the following form:

$$\pi_{assembly} = \left[\frac{\lambda_1}{\varepsilon_1 - 1} + 1\right] \times \frac{1}{\alpha(s_1)+\beta(s_1)} \times q^* \times [\theta_1] \times [\theta_2] - \left\{(q^*)^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2] + \mathrm{F}(s_1)\right\}$$

(28)

Dividing q^* by both sides:, we obtain the expression of the average profitability function for the Manufacturer:

$$\frac{\pi_{assembly}}{q^*} = \underbrace{\left\{\left[\frac{\lambda_1}{\varepsilon_1 - 1} + 1\right] \times \frac{1}{\alpha(s_1)+\beta(s_1)} \times [\theta_1] \times [\theta_2]\right\}}_{Capability\ effect\ of\ upstream\ Assembly\ firm} - \underbrace{\left\{\underbrace{(q^*)^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2]}_{variable\ cost\ effect} + \underbrace{\frac{\mathrm{F}(s_1)}{q^*}}_{endogenous\ sunk\ cost\ effect}\right\}}_{Cost\ effect\ of\ upstream\ Assembly\ firm}$$

(29)

Similarly, we can derive the expression of the average profitability function for the Retailer:

$$\frac{\pi_{marketing}}{q^*} = p_m(q^*) - p^*(s_1, q^*) - \frac{C(s_2, q^*)}{q^*} = \underbrace{\left\{\frac{1}{\alpha(s_1)+\beta(s_1)} \times (q^*)^{\frac{1-\alpha(s_2)-\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times [\theta_1] \times [\theta_2] \times \left\{\left[\frac{\varepsilon_1 + \lambda_1 - 1}{\varepsilon_1 - 1}\right] \times \frac{1}{\varepsilon_2 - 1} - \frac{\lambda_1 \varepsilon_2}{(\varepsilon_1 - 1)(\varepsilon_2 - 1)}\right\}\right\}}_{Capability\ effect\ of\ downstream\ marketing\ firm} -$$

$$\underbrace{\left\{\underbrace{\left\{\left[(q^*)^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \times \theta_3 \times \theta_4\right]\left\{\left[\frac{1}{\alpha(s_2)+\beta(s_2)}\right] - 1\right\}\right\}}_{variable\ cost\ effect} + \underbrace{\frac{\mathrm{F}(s_2)}{q^*}}_{endogenous\ sunk\ cost\ effect}\right\}}_{cost\ effect\ of\ downstream\ marketing\ firm}$$

(30)

Proposition 2: *Under joint-profit maximizing contracting choices as well as the normalization of fixing quantity* $q^* = 1$,r=1, *the average profitability of the downstream retailer is higher than that of the Manufacturer if and only if*

1. $\varepsilon_1 < \varepsilon_2$

2. $\frac{1}{L(s_1, 1)} < \left\{\frac{\alpha(s_1) + \beta(s_1)}{\beta(s_1)[F(s_2) - F(s_1)]}\right\}^{\frac{\beta(s_1)}{\alpha(s_1)}}$ for $\alpha(s_2) + \beta(s_2) = 1$

3. $\frac{1}{[L(s_2,1)]} > \left\{\frac{\beta(s_2)}{\beta(s_2)+\alpha(s_2)} - \left[\frac{2\beta(s_2)[\alpha(s_1)+\beta(s_1)]}{\beta(s_1)[\beta(s_2)+\alpha(s_2)]}\right] \times \left[\frac{1}{[L(s_1,1)]}\right]^{\frac{\alpha(s_1)}{\beta(s_1)}}\right\}^{\frac{\beta(s_1)}{\alpha(s_2)}}$ for $\alpha(s_2) + \beta(s_2) > 1$

In summary, when both capability effect and cost effect of the downstream retailer dominates the counterpart effects of the Manufacturer

For the proof of Proposition 2, please see Appendix D.

Proposition 2 implies that the downstream retailer is more profitable than the Manufacturer when both capability effect and cost effect of Retailer have to dominate the counterpart effects of Manufacturer. Regarding the dominance of capability effect, the Retailer has to have higher monopolistic market power in the final market compared with that of the monosoponist market power in the intermediate input market. This makes sense as if it has higher monopolistic market power: it can then extract additional surplus from the consumers.

Secondly, in terms of the dominance of the cost effects, if the downstream retailer exhibits constant returns to scale, the retailer could earn higher level of profitability if and only if the Manufacturer is very labour intensive. This implies the downstream firm faces a constant long-run average cost and for the Manufacturer it implies the amount of labour it employed $L(s_1, 1)$ is very large. When the manufacturer employs excessive amount of labours, the average product of the labour of the Manufacturer would fall. This paper also assumed the gap between the levels of endogenous sunk cost spending across upstream and downstream stage must be big enough that narrowing this gap is not going to be a valid comparative static. The same situation applies to the value of $\alpha(s_1) + \beta(s_1)$ as we have restricted our attention to constant returns of scale, so varying this value as well would be an invalid comparative static.

If Retailer exhibits increasing returns to scale, the Retailer is more capital-intensive and has less labour; it becomes more profitable than Manufacturers as its average labour productivity is higher. On the other hand, it is easy to see that once the Manufacturer employs excessive amount of labour, then the right hand side in the third part of proposition 2 becomes smaller, which increases the inequality.

8. Empirical Evidences

9. Conclusion

This paper provides a first theoretical look at the profit sharing along the global supply chains at the firm-level from both consumption and production perspective. The divisions of the gains in global supply chains, as one of the most important phenomena so far during the process of globalization, has not been studied in a unified framework. The literature either focuses on the income distribution among interdependent nations at the country level or a firm-level analysis concentrated on the consumption side gains such as the market power.

From the theories posed in this paper it is possible to reach a number of important conclusions, including the downstream retailer is more profitable than the Manufacturer if and only if, Retailer has higher monopolistic market power in the final goods market compared with the intermediate input market. In such a situation it would extract higher surplus from the consumers rather than Manufacturers. Regarding the production side gains, if Retailer exhibits the constant return of scale, downstream retailer's cost effect dominates the upstream Manufacturer's cost if, and only if, Manufacturer is excessively labour intensive; this leads to the lower average product of labour compared with downstream Retailer.

Since the downstream retailer is more capital-intensive and hires more skilled labour (and increasing returns to scale), its average product of labour is therefore high enough to maintain a higher level of profitability compared with upstream Manufacturer.

There are considerable prospects for the future research, divided into two areas: one is the technical aspect. It is possible to extend the model into the 3 production stages case in which R&D stage is also included. It was not possible to examine this here because this paper is constrained The other aspect could be more methodology-oriented, in which researchers may use other contracting choices apart from the quantity fixing such as two-part tariff or resale price maintenance.

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Appendix

Appendix A.

Proof of Lemma 1:

First of all, we begin the proof by taking the second order condition of the profit function and let it smaller than 0. we then could obtain the following condition:

$$\frac{\partial p(s_1,q)}{\partial q} - \left\{\frac{1-\alpha(s_1)-\beta(s_1)}{[\alpha(s_1)+\beta(s_1)]^2}\right\}(q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times (\theta_1) \times (\theta_2) \times \left[\frac{\epsilon_1}{\epsilon_1-1}\right] < 0 \tag{A.1}$$

Where $\theta_1 = \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]$, $\theta_2 = \left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} + \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]$

Since q^* is a forcing quantity, thus I could also denote k=$(q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}$ which is a parameter.

So (A.1) becomes: $\frac{\partial p(s_1,q)}{\partial q} - \left\{\frac{1-\alpha(s_1)-\beta(s_1)}{[\alpha(s_1)+\beta(s_1)]^2}\right\} \times k \times (\theta_1) \times (\theta_2) \times \left[\frac{\epsilon_1}{\epsilon_1-1}\right] < 0$ (A.2)

Multiply $[\alpha(s_1)+\beta(s_1)]^2$ by both sides of (A.2) and substitute the $\frac{\partial p(s_1,q)}{\partial q} = -\frac{1}{\epsilon_1}\frac{q}{p}$ into (A.1), we could rearrange the (A.2) as the following:

$$1-\alpha(s_1)-\beta(s_1) > \frac{-[\alpha(s_1)+\beta(s_1)]^2 \times \frac{1}{\epsilon_1}\frac{q}{p}}{k \times (\theta_1) \times (\theta_2) \times \left[\frac{\epsilon_1}{\epsilon_1-1}\right]} \tag{A.3}$$

(A.3) could be further reduced to the following form:

$$1-\alpha(s_1)-\beta(s_1) > \underbrace{-[\alpha(s_1)+\beta(s_1)]^2}_{<0} \times \left[\frac{q(\epsilon_1-1)}{k\times(\theta_1)\times(\theta_2)\times(\epsilon_1)^2\times p}\right] \tag{A.4}$$

We know that a monopolistic firm would never produce at the region where price elasticity of demand in inelastic in which 0<ϵ_1<1.[16]

Hence if 0<ϵ_1<1, $\left[\frac{q(\epsilon_1-1)}{k\times(\theta_1)\times(\theta_2)\times(\epsilon_1)^2\times p}\right] < 0$, then
$\underbrace{-[\alpha(s_1)+\beta(s_1)]^2}_{<0} \times \left[\frac{q(\epsilon_1-1)}{k\times(\theta_1)\times(\theta_2)\times(\epsilon_1)^2\times p}\right] > 0$, so it is impossible that $\alpha(s_1) +$

$\beta(s_1)$<1

In other words, if $\epsilon_1 = 1$,then $\alpha(s_1)+\beta(s_1) = 1$. If $\epsilon_1 > 1$, then $\alpha(s_1)+\beta(s_1) >$

1.

Nonetheless, if $\epsilon_1 = 1$, the first order condition implied by (A.1) would collapse and one could not find the optimal forcing quantity under the bilateral contracting choices for the Manufacturer. So the only case left is $\epsilon_1 > 1$ implying that $\alpha(s_1)+\beta(s_1) >$

1.

Proof completes.

Appendix B.

Proof of Lemma 2:

We begin this proof by taking the second order condition of the profit function implied by (22) and let it smaller than 0. After plugging the forcing quantity into the second order condition, we then could obtain the following condition:

[16] The reason of why a monopolist firm would never produce at the region where the price elasticity of demand is inelastic is as follows: Consider the following marginal revenue expression for a monopolist:
MR(q)=$\frac{\partial R(q)}{\partial q}$=$p'(q)q+p(q) = \frac{q(p)}{q'(p)}+p = \frac{p}{p}\frac{q(p)}{q'(p)} = p\left[\frac{1}{q'(p)}\frac{q(p)}{p}+1\right]$=p($\frac{1}{\epsilon(p)}+1$). Since a monopolist would never produce at the level in which Marginal revenue is negative, so it must be the case that p($\frac{1}{\epsilon(p)}+1$)≥ 0 This would lead to the following result: $\epsilon(p) \le -1$, so $|\epsilon(p)| \ge 1$.

Step 1:

$$\left\{\frac{1}{[\alpha(s_2)+\beta(s_2)]^2}(q^*)^{\frac{1-2\alpha(s_2)-2\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4 + \left\{\frac{\lambda_1}{[\alpha(s_1)+\beta(s_1)]^2}(q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2] \times \left[\frac{\epsilon_1}{\epsilon_1-1}\right]\right\} + \right.$$

$$\left. \left\{\frac{\lambda_2[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}\ (q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2]\right\}\right\} \times \left[\frac{\epsilon_2}{\epsilon_2-1}\right] < 0 \qquad \text{(B.1)}$$

Since it is a must that $\epsilon_2 > 1$, then $\left[\frac{\epsilon_2}{\epsilon_2-1}\right] > 0$. So we have to ensure that

$$\left\{\frac{1-\alpha(s_2)-\beta(s_2)}{[\alpha(s_2)+\beta(s_2)]^2}(q^*)^{\frac{1-2\alpha(s_2)-2\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4 + \left\{\frac{\lambda_1[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}(q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2] \times \right.\right.$$

$$\left.\left. \left[\frac{\epsilon_1}{\epsilon_1-1}\right]\right\} + \left\{\frac{\lambda_2[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}\ (q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2]\right\}\right\} < 0$$

(B.2)

Step 2. Now guess that if $\alpha(s_2) + \beta(s_2) = 1$, given that $\alpha(s_1) + \beta(s_1) > 1$

Then, $$\left\{0 + \underbrace{\left\{\frac{\lambda_1[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}(q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1] \times [\theta_2] \times \left[\frac{\epsilon_1}{\epsilon_1-1}\right]\right\}}_{<0} + \right.$$

$$\left. \underbrace{\left\{\frac{\lambda_2[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}\ (q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2]\right\}}_{<0}\right\} < 0$$

So (B.2) could be satisfied if the Retailer exhibits the constant return of scale.

Secondly, guess that if $\alpha(s_2) + \beta(s_2) > 1$,

The condition of (B.2) is satisfied as all the 3 terms in the bracket are negative.

Now guess that if $\alpha(s_2) + \beta(s_2) < 1$

Then condition (B.2) could be satisfied if and only if

$$\left|\frac{1-\alpha(s_2)-\beta(s_2)}{[\alpha(s_2)+\beta(s_2)]^2}(q^*)^{\frac{1-2\alpha(s_2)-2\beta(s_2)}{\alpha(s_2)+\beta(s_2)}}\times\theta_3\times\theta_4\right|<\left|\left\{\frac{\lambda_1[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}(q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\times[\theta_1]\times[\theta_2]\times\left[\frac{\epsilon_1}{\epsilon_1-1}\right]\right\}+\left\{\frac{\lambda_2[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}(q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1]\times[\theta_2]\right\}\right|$$

(B.3)

Thus,

$$\frac{1-\alpha(s_2)-\beta(s_2)}{[\alpha(s_2)+\beta(s_2)]^2}(q^*)^{\frac{1-2\alpha(s_2)-2\beta(s_2)}{\alpha(s_2)+\beta(s_2)}}\times\theta_3\times\theta_4<-\left\{\frac{\lambda_1[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}(q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}[\theta_1]\times[\theta_2]\times\left[\frac{\epsilon_1}{\epsilon_1-1}\right]\right\}-\frac{\lambda_2[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}(q^*)^{\frac{1-2\alpha(s_1)-2\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\times[\theta_1]\times[\theta_2]$$

(B.4)

Rearrange (B.4), we could obtain the following condition

$$0<(q^*)^{\frac{[\alpha(s_1)+\beta(s_1)]-[\alpha(s_2)+\beta(s_2)]}{[\alpha(s_1)+\beta(s_1)][\alpha(s_2)+\beta(s_2)]}}<\frac{\frac{[1-\alpha(s_1)-\beta(s_1)]}{[\alpha(s_1)+\beta(s_1)]^2}\times\left[-\lambda_1\times[\theta_1]\times[\theta_2]\times\left[\frac{\epsilon_1}{\epsilon_1-1}\right]-\lambda_2\times[\theta_1]\times[\theta_2]\right]}{\frac{1-\alpha(s_2)-\beta(s_2)}{[\alpha(s_2)+\beta(s_2)]^2}\times\theta_3\times\theta_4} \quad \text{(B.5)}$$

Since $\left[-\lambda_1\times[\theta_1]\times[\theta_2]\times\left[\frac{\epsilon_1}{\epsilon_1-1}\right]-\lambda_2\times[\theta_1]\times[\theta_2]\right]<0$, then it must be the case that

$1-\alpha(s_2)-\beta(s_2)<0$ which contradicts with the statement $\alpha(s_2)+\beta(s_2)<1$.

So the decreasing return of scale is impossible.

Proof completes

Appendix C

Take the derivative of (26) with respect to q and let it equal to 0, we could obtain the first order condition as the following:

$$p_f(q)+\frac{\partial p_f(q)}{\partial q}=MC(s_1,q)+MC(s_2,q) \quad \text{(C.1)}$$

Plug (9) and (21) into the (C.1) as well as factor out the $p_m(q)$ on the right side of (C.1), I could obtain the following condition:

$$p_f(q) = (\frac{\epsilon_2}{\epsilon_2-1})\left\{\left[\frac{1}{\alpha(s_1)+\beta(s_1)}\ q^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \theta_1 \times \theta_2\right] + \left[\frac{1}{\alpha(s_2)+\beta(s_2)} q^{\frac{1-\alpha(s_2)-\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4\right]\right\}$$

(C.2)

Thus,

$$(A)^{\frac{1}{\epsilon_2}} q^{-\frac{1}{\epsilon_2}} == (\frac{\epsilon_2}{\epsilon_2-1})\left\{\left[\frac{1}{\alpha(s_1)+\beta(s_1)}\ q^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \theta_1 \times \theta_2\right] + \left[\frac{1}{\alpha(s_2)+\beta(s_2)} q^{\frac{1-\alpha(s_2)-\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4\right]\right\}$$

(C.3)

Plug the forcing quantity q^* into (C.3), we know that the forcing quantity must satisfy the following:

$$(A)^{\frac{1}{\epsilon_2}} (q^*)^{-\frac{1}{\epsilon_2}} == (\frac{\epsilon_2}{\epsilon_2-1})\left\{\left[\frac{1}{\alpha(s_1)+\beta(s_1)}\ (q^*)^{\frac{1-\alpha(s_1)-\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \theta_1 \times \theta_2\right] + \left[\frac{1}{\alpha(s_2)+\beta(s_2)} (q^*)^{\frac{1-\alpha(s_2)-\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \theta_3 \times \theta_4\right]\right\} \quad \text{(C.4)}$$

Proof completes.

Appendix D

Step 1.

We begin this proof by firstly setting up the following inequality which implies the dominance of capability effect of the downstream retailer over the counterpart effect of the Manufacturer:

$$\underbrace{\left\{\frac{1}{\alpha(s_1)+\beta(s_1)} \times (q^*)^{\frac{1-\alpha(s_2)-\beta(s_2)}{\alpha(s_2)+\beta(s_2)}} \times [\theta_1] \times [\theta_2] \times \left\{\left[\frac{\varepsilon_1+\lambda_1-1}{\varepsilon_1-1}\right] \times \frac{1}{\varepsilon_2-1} - \frac{\lambda_1\varepsilon_2}{(\varepsilon_1-1)(\varepsilon_2-1)}\right\}\right\}}_{Capability\ effect\ of\ downstream\ marketing\ firm} >$$

$$\underbrace{\left\{\left[\frac{\lambda_1}{\varepsilon_1-1}+1\right] \times \frac{1}{\alpha(s_1)+\beta(s_1)} \times [\theta_1] \times [\theta_2]\right\}}_{Capability\ effect\ of\ upstream\ Assembly\ firm}$$

(D.1)

Normalizing $q^* = 1$ and (D.1) could be further reduced to the following form:

$$\left\{\left[\frac{\varepsilon_1+\lambda_1-1}{\varepsilon_1-1}\right] \times \frac{1}{\varepsilon_2-1} - \frac{\lambda_1\varepsilon_2}{(\varepsilon_1-1)(\varepsilon_2-1)}\right\} > \left[\frac{\lambda_1}{\varepsilon_1-1}+1\right] \tag{D.2}$$

(D.2) could be rewritten as the following:

$$\frac{\varepsilon_1+\lambda_1-1-\lambda_1\varepsilon_2}{(\varepsilon_2-1)} > \lambda_1+\varepsilon_1-1 \tag{D.3}$$

(D.3) could be rearranged as the following:

$$2\lambda_1(\varepsilon_2-1) > (\varepsilon_1-1)\,(\varepsilon_2-2) \tag{D.4}$$

Substitute $\lambda_1 = 1-\lambda_2$ into (D.4), we could obtain the following:

$$2(1-\lambda_2)(\varepsilon_2-1) > (\varepsilon_1-1)\,(\varepsilon_2-2) \tag{D.5}$$

Expand the (D.5) by both sides and rearrange it, (D.5) becomes:

$$2(\varepsilon_2-\varepsilon_1)+2\lambda_2(1-\varepsilon_2) > \varepsilon_2(1-\varepsilon_1) \tag{D.6}$$

Then, from (D.6) we know that

$$\frac{2[\varepsilon_2-\varepsilon_1+\lambda_2-\lambda_2\varepsilon_2]}{\varepsilon_2} > (1-\varepsilon_1) \tag{D.7}$$

As $(1-\varepsilon_1) < 0$

So we then have 2 cases:

$$\begin{cases} \frac{2[\varepsilon_2-\varepsilon_1+\lambda_2-\lambda_2\varepsilon_2]}{\varepsilon_2} > 0 \\ \frac{2[\varepsilon_2-\varepsilon_1+\lambda_2-\lambda_2\varepsilon_2]}{\varepsilon_2} < 0 \end{cases} \tag{D.8}$$

For the first part of (D.8), it could be seen that we would obtain the following

$$\varepsilon_2 - \varepsilon_1 + \lambda_2 - \lambda_2\varepsilon_2 > 0$$

Which is $\lambda_2 > \frac{\varepsilon_1-\varepsilon_2}{1-\varepsilon_2}$. As 1>λ_2, this implies that $\varepsilon_1 < 1$ which is impossible. So we could ignore the first part of (D.8).

For the second part of (D.8), we obtain that $\lambda_2 < \frac{\varepsilon_1-\varepsilon_2}{1-\varepsilon_2}$ as 0<λ_2, so $\frac{\varepsilon_1-\varepsilon_2}{1-\varepsilon_2} > 0$, then it could be obtained that $\varepsilon_1 - \varepsilon_2 < 0$ which implies $\varepsilon_1 < \varepsilon_2$

Step 2

Now let us proceed to the proof of the second condition for the case (1). If the cost effects of the downstream retailer dominate, then the total cost of the retailer must be strictly lower than that of the Manufacturer Then the following inequality must hold:

$$\underbrace{\left\{ \underbrace{\left\{ \left[(q^*)^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \times \theta_3 \times \theta_4 \right] \left\{ \left[\frac{1}{\alpha(s_2)+\beta(s_2)} \right] - 1 \right\} \right\}}_{average\ variable\ cost\ effect} + \underbrace{\frac{\mathrm{F}(s_2)}{q^*}}_{endogenous\ sunk\ cost\ effect} \right\}}_{cost\ effect\ of\ downstream\ marketing\ firm} < \underbrace{\left\{ \underbrace{(q^*)^{\frac{1}{\alpha(s_1)+\beta(s_1)}} \times [\theta_1] \times [\theta_2]}_{average\ variable\ cost\ effect} + \underbrace{\frac{\mathrm{F}(s_1)}{q^*}}_{endogenous\ sunk\ cost\ effect} \right\}}_{Cost\ effect\ of\ upstream\ Assembly\ firm} \tag{D.9}$$

Now there are two cases to consider here. Case 1 is when $\alpha(s_2) + \beta(s_2) = 1$. Case 2 is when $\alpha(s_2) + \beta(s_2) > 1$.

Case 1. $\alpha(s_2) + \beta(s_2) = 1$

If the retailer exhibits the constant return of scale, then (D.9) reduces to the following form after normalizing the forcing quantity to 1:

$$\mathrm{F}(s_2) < [\theta_1] \times [\theta_2] + \mathrm{F}(s_1) \quad \text{(D.10)}$$

From (D.10), we know that $\mathrm{F}(s_2) - \mathrm{F}(s_1) < [\theta_1] \times [\theta_2]$

Which is $\mathrm{F}(s_2) - \mathrm{F}(s_1) < \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} r^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \times \left[\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{\beta(s_1)}{\alpha(s_1)+\beta(s_1)}} + \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right]$

(D.11)

As r=1, (D.11) could be rearranged as the following:

$$\mathrm{F}(s_2) - \mathrm{F}(s_1) < w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left[\frac{\alpha(s_1)}{\beta(s_1)} + 1\right] \quad \text{(D.12)}$$

Which is

$$\mathrm{F}(s_2) - \mathrm{F}(s_1) < w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left[\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}\right] \quad \text{(D.13)}$$

Take the log by both sides for (D.13), then we could obtain the following:

$$\log[\mathrm{F}(s_2) - \mathrm{F}(s_1)] < \frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)} \log w(s_1) + \log[\alpha(s_1) + \beta(s_1)] - \log[\beta(s_1)] - \left\{\left[\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)} \log\alpha(s_1) - \frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)} \log\beta(s_1)\right]\right\} \quad \text{(D.14)}$$

(D.14) could be rewritten as the following:

$$\log[\mathrm{F}(s_2) - \mathrm{F}(s_1)] < \frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)} \left\{\log\left[\frac{w(s_1)\beta(s_1)}{\alpha(s_1)}\right]\right\} + \log\left[\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}\right] \quad \text{(D.15)}$$

(D.15) could be further reduced to:

$$\log[\mathrm{F}(s_2) - \mathrm{F}(s_1)] < \log\left\{\left[\frac{w(s_1)\beta(s_1)}{\alpha(s_1)}\right]^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}\right\} \quad \text{(D.16)}$$

which is $\mathrm{F}(s_2) - \mathrm{F}(s_1) < \left[\frac{w(s_1)\beta(s_1)}{\alpha(s_1)}\right]^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}$ (D.17)

Plug $w(s_1) = \frac{\alpha(s_1)}{\beta(s_1)[L(s_1,1)]^{\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}}}$ into (D.17),

we then obtain the inequality for the average labour productivity condition :

$$\frac{1}{L(s_1,1)} < \left\{\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)[F(s_2)-F(s_1)]}\right\}^{\frac{\beta(s_1)}{\alpha(s_1)}} \quad \text{(D.18)}$$

Case 2. $\alpha(s_2) + \beta(s_2) > 1$

If $\alpha(s_2) + \beta(s_2) > 1$, then in order to make sure (D.9) holds, it must be the case that

$$[\theta_3] \times [\theta_4] \times \left[\frac{1}{\alpha(s_2)+\beta(s_2)} - 1\right] < [\theta_1] \times [\theta_2] + \mathrm{F}(s_1) - \mathrm{F}(s_2) \quad \text{(D.19)}$$

So $\left[\frac{1}{\alpha(s_2)+\beta(s_2)} - 1\right] < \frac{[\theta_1]\times[\theta_2]+\mathrm{F}(s_1)-\mathrm{F}(s_2)}{[\theta_3]\times[\theta_4]}$ (D.20)

As 0< $\alpha(s_2) < 1$, 0< $\beta(s_2) < 1$, this implies that $\left[\frac{1}{\alpha(s_2)+\beta(s_2)} - 1\right] > -\frac{1}{2}$

This then leads to the following inequality:

$$\frac{[\theta_1]\times[\theta_2]+\mathrm{F}(s_1)-\mathrm{F}(s_2)}{[\theta_3]\times[\theta_4]} > -\frac{1}{2} \quad \text{(D.21)}$$

(D.21) could be rearranged as the following:

$$2[F(s_2) - \mathrm{F}(s_1)] < [\theta_3] \times [\theta_4] + 2 \times [\theta_1] \times [\theta_2] \quad \text{(D.22)}$$

Take log by both sides for (D.22)

$$\log(2)+\log[\mathrm{F}(s_2) - \mathrm{F}(s_1)] < \log\{[\theta_3] \times [\theta_4] + 2 \times [\theta_1] \times [\theta_2]\} \quad \text{(D.23)}$$

which is $\log\{[\theta_3] \times [\theta_4] + 2 \times [\theta_1] \times [\theta_2]\} > \log\big[2[\mathrm{F}(s_2) - \mathrm{F}(s_1)]\big]$ (D.24)

We know that according to assumption 2, $F(s_2) - F(s_1) > \frac{1}{2}$, then it must be the case that $\log\big[2[\mathrm{F}(s_2) - \mathrm{F}(s_1)]\big]>0$

This implies that $\log\{[\theta_3] \times [\theta_4] + 2 \times [\theta_1] \times [\theta_2]\} > 0$ (D.25)

From (25), we know that $\{[\theta_3] \times [\theta_4] + 2 \times [\theta_1] \times [\theta_2]\}>1$ (D.26)

(D.26) could be rewritten as the following, when $q^* = 1$, r=1:

$$w(s_2)^{\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \left\{\left(\frac{\alpha(s_2)}{\beta(s_2)}\right)^{\frac{-\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \left[\frac{\alpha(s_2)}{\beta(s_2)} + 1\right]\right\}>1-2\left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \times \left\{\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left[\frac{\alpha(s_1)}{\beta(s_1)} + 1\right]\right\} \quad \text{(D.27)}$$

Take log by both sides for (D.27):

$$\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}\log w(s_2) - \frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}\log\left(\frac{\alpha(s_2)}{\beta(s_2)}\right) + \log\left[\frac{\alpha(s_2)+\beta(s_2)}{\beta(s_2)}\right]>\log\left\{1 - 2\left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \times \left\{\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left[\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}\right]\right\}\right\} \quad \text{(D.28)}$$

(D.28) could be further reduced to the following:

$$\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}\left[\log w(s_2) - \log\left(\frac{\alpha(s_2)}{\beta(s_2)}\right)\right]++\log\left[\frac{\alpha(s_2)+\beta(s_2)}{\beta(s_2)}\right]> \log\left\{1 - 2\left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \times \left\{\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left[\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}\right]\right\}\right\}$$

(D.29)

Which is the following:

$$\log\left[\frac{w(s_2)\beta(s_2)}{\alpha(s_2)}\right]^{\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}}+\log\left[\frac{\alpha(s_2)+\beta(s_2)}{\beta(s_2)}\right] > \log\left\{1 - 2\left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \times \left\{\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left[\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}\right]\right\}\right\} \quad \text{(D.30)}$$

(D.30) could be rewritten as the following:

$$\left\{\left[\frac{w(s_2)\beta(s_2)}{\alpha(s_2)}\right]^{\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}} \times \frac{\alpha(s_2)+\beta(s_2)}{\beta(s_2)}\right\}>1 - 2\left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \times \left\{\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left[\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}\right]\right\}$$

(D.31)

(D.31) could be rearranged as follows:

$$\left[\frac{w(s_2)\beta(s_2)}{\alpha(s_2)}\right]^{\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}} >$$

$$\frac{\beta(s_2)}{\beta(s_2)+\alpha(s_2)} - 2\left[\frac{\beta(s_2)}{\beta(s_2)+\alpha(s_2)}\right]\left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \times \left\{\left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}} \times \left[\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}\right]\right\}$$

(D.32)

This is to say:

$$\left[\frac{w(s_2)\beta(s_2)}{\alpha(s_2)}\right]^{\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}} > \frac{\beta(s_2)}{\beta(s_2)+\alpha(s_2)} - \left[\frac{2\beta(s_2)[\alpha(s_1)+\beta(s_1)]}{\beta(s_1)[\beta(s_2)+\alpha(s_2)]}\right] \times \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \times \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}$$

(D.33)

Whence

$$\left[\frac{w(s_2)\beta(s_2)}{\alpha(s_2)}\right]^{\frac{\alpha(s_2)}{\alpha(s_2)+\beta(s_2)}} + \left\{\left[\frac{2\beta(s_2)[\alpha(s_1)+\beta(s_1)]}{\beta(s_1)[\beta(s_2)+\alpha(s_2)]}\right] \times \left[w(s_1)^{\frac{\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right] \times \left(\frac{\alpha(s_1)}{\beta(s_1)}\right)^{\frac{-\alpha(s_1)}{\alpha(s_1)+\beta(s_1)}}\right\} > \frac{\beta(s_2)}{\beta(s_2)+\alpha(s_2)}$$

(D.34)

From the expression for the conditional input demand for labour at both Assembly stage and Marketing stage, the wage level at each stage corresponds to

$$w(s_1) = \frac{\alpha(s_1)}{\beta(s_1)[L(s_1,1)]^{\frac{\alpha(s_1)+\beta(s_1)}{\beta(s_1)}}} \quad w(s_2) = \frac{\alpha(s_2)}{\beta(s_2)[L(s_2,1]^{\frac{\alpha(s_2)+\beta(s_2)}{\beta(s_2)}}} \qquad \text{(D.35)}$$

Plug (D.35) into (D.34), we obtain the following:

$$\left[\frac{2\beta(s_2)[\alpha(s_1)+\beta(s_1)]}{\beta(s_1)[\beta(s_2)+\alpha(s_2)]}\right] \times \left[\frac{1}{[L(s_1,1)]}\right]^{\frac{\alpha(s_1)}{\beta(s_1)}} > \frac{\beta(s_2)}{\beta(s_2)+\alpha(s_2)} - \left[\frac{1}{[L(s_2,1)]}\right]^{\frac{\alpha(s_2)}{\beta(s_2)}} \qquad \text{(D.36)}$$

So (D.36) could be arranged as follows:

$$\frac{1}{[L(s_2,1)]} > \left\{\frac{\beta(s_2)}{\beta(s_2)+\alpha(s_2)} - \left[\frac{2\beta(s_2)[\alpha(s_1)+\beta(s_1)]}{\beta(s_1)[\beta(s_2)+\alpha(s_2)]}\right] \times \left[\frac{1}{[L(s_1,1)]}\right]^{\frac{\alpha(s_1)}{\beta(s_1)}}\right\}^{\frac{\beta(s_1)}{\alpha(s_2)}} \qquad \text{(D.37)}$$

Proof Completes