Analysis of Lower Value-Added Rate with Increasing Imported Intermediate Goods in China's Industry *

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Abstract: The declining of valued-added rate in China implies its lower position in the industrial chain despite of its explosive economic growth. Based on China's non-competitive input-output tables, we find that China's valued-added rate is negatively correlated with imported intermediate goods share which is increasing with vertical specialization. To explain this phenomenon, we propose a two-country model, in which home country acts as a price taker. The main conclusions can been drawn as follows: first, the cost difference makes vertical specialization possible, the industry with higher cost will transfer to the lower cost country; second, value-added rate of a sector depends on the price of intermediate goods, final goods and technology, while the rate of the whole industry is determined by sectors' value-added rates and their corresponding share in final good; third, vertical specialization doesn't necessarily change a sector's value-added rate but increases the share of low value-added rate sectors in final good.

Key words: intermediate goods; value-added rate; fixed prices

1. Introduction

Value-added rate—the share of new value-added in output—has long been a comprehensive index which measures input-output efficiency of an economy as a whole. Though China's manufacturing industry output in 2010 has overtaken the U.S. measured by the official exchange rate, ranking the first in global manufacturing industry, it is an undeniable fact that China's industry is big but not strong. Figure 1 shows the value-added rate of China, Japan, and the USA. The rate of USA reaches 0.4 or so, the highest among the three; the rate of Japan comes next to that of the USA, increasing gradually; the rate of China is the lowest, and the gap between China and the former two is still growing. To change this situation, the State Council of China released a

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decision of *China Industrial Transformation and upgrading plan (2011 - 2015)* in January 2012, which intends to increase value-added rate to around 8%.

There is a burgeoning literature which seeks to understand the declining trend of China's value-added rate despite explosive economic growth. Shen and Wang(2006) distinguish intermediate goods into foreign intermediate goods and domestic ones, and find the decline of China's value-added rate is generated by the newly-increased foreign intermediate goods. Liu(2011)investigates the declining trend of value-added rate from 1987 to 2007 under the framework of non-competitive input-output by SDA and LMDI methods. It has been concluded that the declining trend of value-added rate is related to the structure change of China's economics, which is the inevitable result of industrialization process. From the final demand perspective, the change of initial input structure and the increasing share of intermediate goods imported from aboard are the main reasons of the declining trend. Yao(2006)indicates that recent years' inflowing FDI of Zhejiang and Jiangsu provinces couldn't promote the industry added value rate of domestic enterprises. In Gao(2010), the most significant positive factor of the high-tech industries' added value is R&D intensity; the negative factor is the distribution of R&D. The main reason for the low value-added rate of China's high-tech industry is the much lower rate of R&D intensity than the OECD countries. In conclusion, two factors affect value-added rate, one is industry technology, the other is the vertical specialization, and vertical specialization affects value-added rate through intermediate goods (Shen, 2006; Liu, 2011).

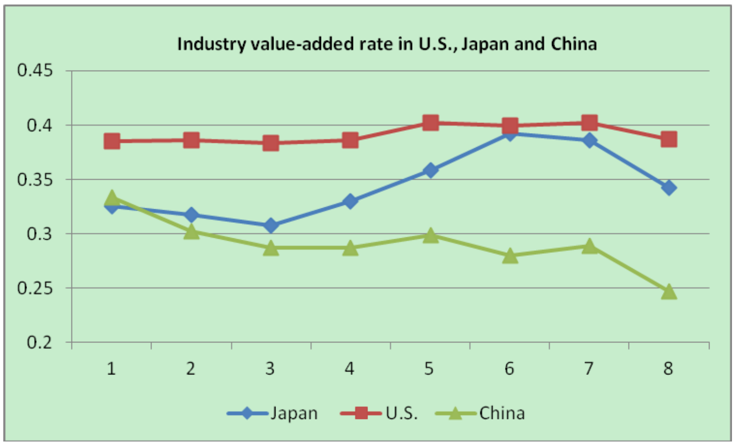


Figure 1 Industry value-added rate in U.S., Japan and China

Notes: Value-added rate in U.S. are from Bureau of Economic Analysis, spanning from 1998 to 2005; that in Japan are calculated from the Japan 1975-2005 input output tables; that in China are calculated from China 1987-2005 input output tables.

Figure 2 shows that the value-added rate is negatively correlated with imported intermediate goods share. Low value-added rate implies China's poor profitability and low-end position in international value chain. The influences of vertical specialization on the developing countries have been broadly studied. The new Core and Periphery Theory proposed by Krugman(1995) indicates that vertical specialization makes the developing countries suffer from real income loss. Rodríguez-Clare(1996) first suggests that multinational corporations affect the developing countries through intermediate goods, the more the intermediate goods, the bigger the impact, under certain conditions, the multinational enterprises will harm these countries. Chakraborty(2003) argues endowment basis for trade becomes crucial in determining trade across stages of production with the capital-rich country a net exporter of specialized intermediate goods and an importer of the final good. The capital-rich country is shown to be immune to distributional conflicts, whereas for the labour-rich country the distributional conflict crucially hinges upon the elasticity of substitution between intermediate goods. Helpman(2004) holds the same view as Chakraborty that for the difference of natural endowments and technology, the intermediate goods will be produced by the low-wage country while the developed country specializes in final good, and they both benefit. Goldberg et al.(2010) investigate the relationship between declines in trade costs, imports of intermediate goods and domestic firm product scope. They estimate India firms make substantial gains from trade through access to new imported inputs.

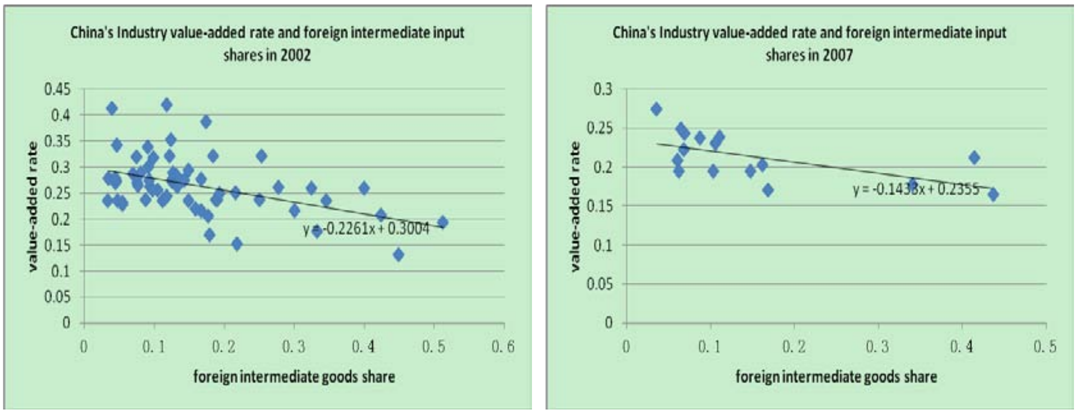


Figure 2 China's industry value-added rate and foreign intermediate goods share

Notes: The data are calculated from China's 2002 and 2007 non-competitive input-output tables constructed by China Bureau of National Statistics.

It should not be denied that vertical specialization brings out increasing output in developed countries and economic growth in developing countries, but the latter will have to be a world fabrication plant if they are only engaged in the export processing without changing. In addition, large-scale imports of intermediate goods would make R&D activities senseless, and deprive the imported of innovation ability and thus locked in the lower end of the production (Yao, 2008). How does vertical specialization affect value-added rate, and what is the relationship between value-added rate and foreign intermediate goods share? Unfortunately, there are few literatures regarding this field. In reality, vertical specialization plays an important role in intermediate goods. Dixit(1982) puts forward that vertical specialization emerge as a result of multi-stage production, in which intermediate goods and primary goods are produced in sequence, while comparative advantage of different regions makes vertical specialization come true. McKinnon(1966) first raises the effect of taxation and subsidiaries of intermediate goods on international trade and economic growth. Soon afterwards, Hueth(1972) considers trade of final goods, as well as intermediate goods. In the analysis of trade in both intermediate and final goods, producers and consumers in a particular trading country gains by having price instability in both markets. Rodríguez-Clare(1996) argues multinationals affect underdeveloped regions through the linkage of intermediate goods. It is shown that the developing regions are more likely to be hurt when goods produced by multination's use intermediate goods intensively. Consequently, it's essential to take intermediate goods of vertical specialization into consideration when analyzing the low value-added rate of China. We will build our model on the foundation of predecessors' efforts on intermediate goods, distinguish foreign intermediate goods and domestic ones, and analyze the effect of high foreign intermediate goods on value-added rate.

The rest of the paper is organized as follows. Section 2 presents a three-stage, two-country trade model of vertical specialization. The model draws from Yi (2003), but the difference from his is that value-added rates of sectors are ununiform and changeable, while in Yi's model they are identical and stable. Section 3 undertakes a simple simulation of our model to investigate whether other factors influence the inverse relationship of industry value-added rate and foreign intermediate goods share. Section 4 concludes.

2. Model

2.1 Firms and Technologies

There are two countries, named Home and Foreign, and two factors of production, capital and labor. The final industry good is produced in three sequential stages. A continuum of goods along the unit interval [0,1] is produced in the first and second stages. Stage-1 goods are intermediate goods for stage-2, where produces the primary goods, and both of these goods are tradable while the final good is non-tradable. Both Home and Foreign possess technologies for producing all the stages. Hence, there are four possible production patterns for the intermediate goods and primary goods on the continuum:

HH Home produces both intermediate goods and primary goods

FF Foreign produces both intermediate goods and primary goods

HF Home produces intermediate goods, Foreign produces primary goods

FH Foreign produces intermediate goods, Home produces primary goods, which is dominant in China

In stage-3, the continuum of stage-2 goods is assembled into the non-traded final good.

Intermediate goods are produced from capital and labor:

$$y_1^i(z) = A_1^i(z) k_1^i(z)^{\alpha} l_1^i(z)^{1-\alpha}, i = H, F, \quad z \in [0,1] \tag{1}$$

where $A_1^i(z)$ is sector z's technology in country i to produce $y_1^i(z)$, and $k_1^i(z)$ and $l_1^i(z)$ are sector z's labor and capital in country i to produce $y_1^i(z)$.

Stage-1 good $y_1^i(z)$ which is tradable across countries is used as intermediate goods into the production of primary good $y_2^i(z)$:

$$y_1(z) \equiv y_1^H(z) + y_1^F(z) = x_1^H(z) + x_1^F(z) \tag{2}$$

where $x_1^i(z)$ is sector z's intermediate goods in country i to use in the second stage.

The intermediate goods with labor and capital are combined in a nested constant elasticity of substitution production function:

$$y_2^i(z) = A_2^i(z)[\gamma(k_2^i(z)^{\alpha} l_2^i(z)^{1-\alpha})^{\rho} + (1-\gamma) x_1^i(z)^{\rho}]^{\frac{1}{\rho}}, \rho < 0, i = H, F, \quad z \in [0,1] \tag{3}$$

where $A_2^i(z)$ is sector z's technology of country i to produce $y_2^i(z)$, and $x_1^i(z)$, $k_1^i(z)$ and $l_1^i(z)$ are sector z's intermediate goods, labor and capital of country i to produce $y_2^i(z)$. γ is the factor parameter of labor and capital, which could be thought as the factor share of primary input, while $1-\gamma$ as the factor share of intermediate goods. ρ is the elasticity of substitution of intermediate and primary goods. Leontief(1947) thinks that intermediate input and primary input can't substitute each other at all, meaning ρ equals 0. Though it's a little extreme, the substitution of intermediate goods and primary one is small in some sense. Therefore, we set the elasticity of substitution of intermediate goods and primary input is less than 1, that is ρ is smaller than 1.

Stage-2 good $y_2^i(z)$ is also tradable:

$$y_2(z) \equiv y_2^H(z) + y_2^F(z) = x_2^H(z) + x_2^F(z) \tag{4}$$

where $x_2^i(z)$ is the quantity of intermediate goods that *z* sector of *i* country needs to produce the final good.

In the third stage, the continuum of stage-2 goods are assembled into the final industry good via a Cobb-Douglass aggregator:

$$Q^i = \int_0^1 x_2^i(z)dz \tag{5}$$

2.2 Competitive Equilibrium

All factor and goods markets are characterized by perfect competition, and home firms take prices as given to participate in the vertical specialization. The markets-clearing conditions are:

$$K^i = \int_0^1 k_1^i(z)dz + \int_0^1 k_2^i(z)dz, i = H, F \tag{6}$$

$$L^i = \int_0^1 l_1^i(z)dz + \int_0^1 l_2^i(z)dz, i = H, F \tag{7}$$

If equations (2)、(4)、(6)、(7) hold, then we can define the competitive equilibrium.

A competitive equilibrium is defined as sectoral factor demands, { $k_1^i(z)$, $l_1^i(z)$, $k_2^i(z)$, $l_2^i(z)$, $x_1^i(z)$, $x_2^i(z)$, $y_1^i(z)$, $y_2^i(z)$, Q^i },that maximize profits given the total supplies of capital and labor, { K^i, L^i } , and prices, { $p_1(z)$, $p_2(z)$, w^i, r^i, P^i ,}, $z \in [0,1]$, $i = H, F$.

To make things simple, we assume the price of home final good is numeraire, i.e. P^H =1。As noted above, there are four types of vertical specialization, and Ricardian comparative advantage forces posits that relative total factor productivities determine whether *HH*, *HF*, *FF*, or *FH* occurs in equilibrium.

Proposition1: Under free trade, Ricardian comparative advantage forces determine the pattern of production and specialization in equilibrium and vertical specialization occurs as long as:

$$\frac{A_1^H(z')}{A_1^F(z')} > \frac{r^{H^\alpha} w^{H^{1-\alpha}}}{r^{F^\alpha} w^{F^{1-\alpha}}} > \frac{[A_2^H(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}}}{[A_2^F(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}}}(HF) \tag{8}$$

$$\frac{A_1^H(z')}{A_1^F(z')} < \frac{r^{H^\alpha} w^{H^{1-\alpha}}}{r^{F^\alpha} w^{F^{1-\alpha}}} < \frac{[A_2^H(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}}}{[A_2^F(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}}}(FH) \tag{9}$$

Proof. Firstly consider the maximum profits of firms in the first two stages, the first order conditions are:

$$r^i = p_1^i(z)\frac{\partial y_1^i(z)}{\partial k_1^i(z)} = p_2^i(z)\frac{\partial y_2^i(z)}{\partial k_2^i(z)}, \forall z \in [0,1] \tag{10}$$

$$w^i = p_1^i(z)\frac{\partial y_1^i(z)}{\partial l_1^i(z)} = p_2^i(z)\frac{\partial y_2^i(z)}{\partial l_2^i(z)}, \forall z \in [0,1] \tag{11}$$

stage-1 good is intermediate goods for stage-2:

$$p_1^i(z) = p_2^i(z)\frac{\partial y_2^i(z)}{\partial x_2^i(z)}, \forall z \in [0,1] \tag{12}$$

The prices of intermediate goods and primary goods are the same in Home and Foreign, so we combine (10) and (11) and have the equation of relative factor price of labor and capital and relative technology:

$$\frac{r^{H^\alpha} w^{H^{1-\alpha}}}{r^{F^\alpha} w^{F^{1-\alpha}}} = \frac{A_1^H(z)}{A_1^F(z)}, \forall z \in [0,1] \tag{13}$$

We define that the relative factor price must equal the relative technology producing the intermediate goods, setting $A_1(z) \equiv \frac{A_1^H(z)}{A_1^F(z)}$, which means first stage relative technology.

In the same way, using (10), (11) and (12), we get:

$$\frac{r^{H^\alpha} w^{H^{1-\alpha}}}{r^{F^\alpha} w^{F^{1-\alpha}}} = \frac{[A_2^H(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}}}{[A_2^F(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}}}, \forall z \in [0,1] \tag{14}$$

We define $A_2(z) \equiv \frac{[A_2^H(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}}}{[A_2^F(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}}}$, which means that the relative technology producing the relative technology producing the primary good.

However, the relative technology in different sectors are not identical, while the relative factor costs are the same in both the first stage and second stage, then there must be some goods produced outside the country, vertical specialization occurs. If the relative factor cost is higher than the relative technology in one certain good, stating that Home technology is lower than that of Foreign. Paying the same factor cost, Foreign will produce more, so producing the good outside is cheaper. It's profitable to produce it in other countries, and vertical specialization occurs. If the relative factor cost is lower than the relative cost conversely, it's profitable to produce it in the home country. For certain good z, the relative technology of first and second stage determines which pattern it belongs, as table 1 shows.

Table 1 Conditions of Vertical Specialization

	$\frac{r^{H^{\alpha}} w^{H^{1-\alpha}}}{r^{F^{\alpha}} w^{F^{1-\alpha}}} < A_1(z)$ Home produces intermediate goods	$\frac{r^{H^{\alpha}} w^{H^{1-\alpha}}}{r^{F^{\alpha}} w^{F^{1-\alpha}}} > A_1(z)$ Foreign produces intermediate goods
$\frac{r^{H^{\alpha}} w^{H^{1-\alpha}}}{r^{F^{\alpha}} w^{F^{1-\alpha}}} < A_2(z)$ Home produces primary good	HH	FH
$\frac{r^{H^{\alpha}} w^{H^{1-\alpha}}}{r^{F^{\alpha}} w^{F^{1-\alpha}}} > A_2(z)$ Foreign produces primary good	HF	FF

Notes: We only list the unequal situation since the equal situation is minor which can be ignored.

2.3 Value-added rate and foreign intermediate goods share

Definition: Value-added rate of sector z is 1 minus share of intermediate goods value in value of total input, which is the sum of value of intermediate goods and value of primary input:

$$\eta^H(z) = 1 - \frac{p_1(z)x_1^i(z)}{p_2(z)y_2^i(z)} \tag{15}$$

Industry value-added rate is one minus share of total value of intermediate goods in total value of total input:

$$\eta^H = 1 - \frac{\int_0^1 p_1(z)x_1^H(z)dz + \int_{z\in FH} p_1(z)x_1^F(z)dz - \int_{z\in HF} p_1(z)x_1^H(z)dz}{\int_0^1 p_2(z)y_2^i(z)dz} \tag{16}$$

Foreign intermediate goods share is foreign intermediate goods divide the total intermediate goods:

$$\lambda^H = \frac{\int_{z\in FH} p_1(z)x_1^F(z)dz}{\int_0^1 p_1(z)x_1^H(z)dz + \int_{z\in FH} p_1(z)x_1^F(z)dz - \int_{z\in HF} p_1(z)x_1^H(z)dz} \tag{17}$$

Since the paper mainly studies the value added-rate of China Industry whose vertical specialization pattern is predominantly export processing (FH), it's exclusively concerned about FH pattern in the following discussion, if without any specific demonstration. On the premise that the results are not affected, we sequence all the firms in the order like this, to all $z \in [0, z^*]$ both the intermediate goods z and primary good z are produced domestically, while $z \in (z^*, 1]$ the firm exports intermediate goods z abroad and produce primary good z at home. Then equation (17) simplifies:

$$\lambda^H = \frac{\int_{z^*}^1 p_1(z)x_1^F(z)dz}{\int_0^1 p_1(z)x_1^H(z)dz + \int_{z^*}^1 p_1(z)x_1^F(z)dz} \tag{18}$$

Proposition 2：Value-added rate of sector *z* depends on the price of intermediate goods and primary good and the technology to produce the primary good, and the value-added rate of the whole industry depends on value-added rate of sectors and their corresponding shares in primary good:

$$\eta^i(z) = \frac{[A_2^H(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}}}{[A_2^H(z')\frac{p_2(z')}{p_1(z')}]^{\frac{\rho}{\rho-1}}} \tag{19}$$

$$\eta^i = \int_0^1 \omega^i(z)\eta(z)dz \tag{20}$$

where $\omega^i(z) = \frac{p_2(z)y_2^i(z)}{\int_0^1 p_2(z)y_2^i(z)dz}$, meaning sector *z*'s share of primary good.

The quantitative relationship of intermediate goods and primary good can be derived from equation (12):

$$\frac{x_1^i(z)}{y_2^i(z)} = [(1-\gamma)^{-1}\frac{p_1(z)}{p_2(z)}A_2^i(z)^{-\rho}]^{\frac{1}{\rho-1}} \tag{21}$$

Multiplying the price we can have the share of intermediate goods in the total input:

$$\frac{p_1(z)x_1^i(z)}{p_2(z)y_2^i(z)} = (1-\gamma)^{-\frac{1}{\rho-1}}[\frac{p_1(z)}{p_2(z)A_2^i(z)}]^{\frac{\rho}{\rho-1}} \tag{22}$$

Substituting (22) into (15), we can solve the value-added rate of single industry:

$$\eta^i = \int_0^1 \frac{p_2(z) y_2^i(z) \eta^i(z) dz}{\int_0^1 p_2(z) y_2^i(z) dz} \tag{23}$$

Q.E.D.

Value-added rate of *z* sector depends on two things, price of intermediate and primary goods and stage-2 technology to produce primary good. The value-added rate increases with declining of intermediate goods price and decreases with uprising of primary good price. From the definition of value-added rate we know that, the higher the intermediate goods price, the higher the intermediate goods share, the lower the valued-added rate is. On the contrary, the higher the primary good price, the higher the same intermediate goods bring about, so the value-added rate is higher. The technology tells the same story.

Industry value-added rate depends on two things, namely value-added rate of sectors and their corresponding share in primary good. Then how does the vertical specialization affect the Industry value-added rate? Does it lower the Industry value-added rate through decreasing value-added rate of single sector just changing the share of primary good? Corollary 1 gives a detailed explanation and proposition 3 provides a quantitative relation about Industry value-added rate and foreign intermediate goods share.

Corollary 1：Vertical specialization does not change the value-added rate of a sector, but value-added rate of all the FH production pattern industries are low. To any $z_1 \in [0, z^*]$ and $z_2 \in (z^*, 1]$, we have:

$$\eta^H(z_1) > \eta^H(z_1) \tag{24}$$

Proof. Equation (19) states the value-added rate of single is only influenced by price and technology, while vertical specialization change neither of these, so vertical specialization does not change value-added rate of single industry.

$z_1 \in [0, z^*]$ indicates that primary good z_1 is produced by HH pattern，while $z_2 \in (z^*, 1]$ indicates that primary good z_2 is produced in FH pattern, the conditions of vertical specialization implies that:

$$A_2(z_1) > \frac{r^{H^\alpha} w^{H^{1-\alpha}}}{r^{F^\alpha} w^{F^{1-\alpha}}} > A_2(z_2) \tag{25}$$

The expression in equation (25) illustrates that the relative technology of producing primary good z_1 is higher than that of producing primary good z_2.

Foreign has the pricing power of the intermediate goods and primary good, and the markets are competitive, then the prices must satisfy:

$$[A_2^F(z_1)\frac{p_2(z_1)}{p_1(z_1)}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}} = [A_2^F(z_2)\frac{p_2(z_2)}{p_1(z_2)}]^{\frac{\rho}{\rho-1}} - (1-\gamma)^{\frac{-1}{\rho-1}} \tag{26}$$

Combining equation (25) and (26), and the definition of relative technology noted before, it shows up immediately:

$$[A_2^H(z_1)\frac{p_2(z_1)}{p_1(z_1)}]^{\frac{\rho}{\rho-1}} > [A_2^H(z_2)\frac{p_2(z_2)}{p_1(z_2)}]^{\frac{\rho}{\rho-1}} \tag{27}$$

Substituting equation (19) into (27) yields equation (25), stating the value-added rate of any HH pattern industry is higher than that of FH pattern. It suggests that vertical specialization affects the industry valued-added rate through changing the share of primary good. Q.E.D.

Proposition 3：Vertical specialization increases the primary good share of sectors with low value-added rate, thus decreases the Industry value-added rate:

$$\eta = \frac{(1-\eta_2)(\theta\eta_1+\eta_2)+\theta(\eta_2-\eta_1)\lambda}{(1-\eta_2)(1+\theta)+\theta(\eta_2-\eta_1)\lambda} \tag{28}$$

where

$$\eta_1 = 1 - \frac{\int_0^{z^*} p_1(z)x_1^H(z)dz}{\int_0^{z^*} p_2(z)y_2^H(z)dz} \tag{29}$$

$$\eta_2 = 1 - \frac{\int_{z^*}^1 p_1(z)x_1^H(z)dz + \int_{z^*}^1 p_1(z)x_1^F(z)dz}{\int_{z^*}^1 p_2(z)y_2^H(z)dz} \tag{30}$$

$$\theta = \frac{\int_0^{z^*} p_2(z)x_2^H(z)dz}{\int_{z^*}^1 p_2(z)x_2^H(z)dz} \tag{31}$$

where η_1 denotes the value-added rate of HH sector, η_2 denotes the value-added rate of FH sector. θ is proportion of FH sector against HH sector in the final good, suggesting the depth of export processing, and the smaller θ is, the deeper home export processing is.

Proof. From equation (16) about the definition of value-added rate, we get (29) and (30) instantly. the expression in equation (5) illustrates that the production of FH and HH sectors should satisfy a certain proportion to process final good:

$$\frac{\int_0^{z^*} p_2(z)y_2^H(z)dz}{\int_{z^*}^1 p_2(z)y_2^H(z)dz - \frac{\int_{z^*}^1 p_1(z)x_1^F(z)dz}{1-\eta_2}} = \frac{\int_0^{z^*} p_2(z)x_2^H(z)dz}{\int_{z^*}^1 p_2(z)x_2^H(z)dz} = \theta \tag{32}$$

All of the homemade primary goods enter final good , while one part of the export processing goods enter it, the other export to Foreign.

From the first-order conditions for the intermediate goods production and the primary good production we get:

$$\int_0^1 p_2(z) y_2^H(z) dz = \int_{z^*}^1 p_1(z) x_1^F(z) dz + r^H K^H + w^H L^H \quad (33)$$

By combining (18), (29), (30) ,(32) and (33), and solving this equation sets, we can get the production of intermediate and primary goods of HH and FH sectors, imported intermediate goods of FH sectors. Substitute the results into equation (16), and then we get the results. Q.E.D.

The partial derivative of Industry value-added rate with respect to foreign intermediate goods share is:

$$\frac{\partial \eta}{\partial \lambda} < 0$$

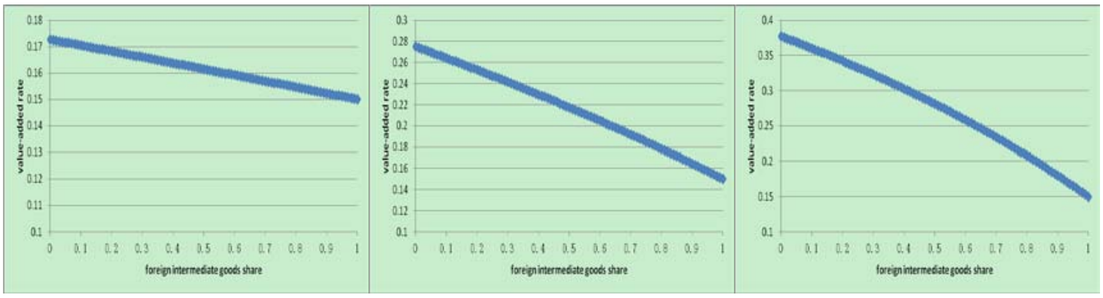
The negative partial deviation is a suggestion, which is consistent with empirical facts about China mentioned in Section 1, that an increase in imported intermediate goods is associated with decrease in value-added rate. Though vertical specialization does not change the value-added rate of single industry, it does increase intermediate goods of industries which are low value-added rate, thus increases the primary good produced and the share of primary good in the production of final good, while Industry value-added rate depends on the value-added rate of single industry and their share of primary good, it decreases as result.

3. Model Simulation

Now we undertake an illustrative simulation to investigate whether the relationship between industry value-added rate and foreign intermediate goods share by our model is influenced by other factors. Firstly, we simplify continuum-of-firms to two firms, η_1 and η_2, corresponding to the complete homemade sector and export processing one in reality, respectively. Considering the complete homemade industry's value-added rate is higher, we use data from that of U.S. Manufacture, which is 0.4. Jones(2011) investigates the value-added rate of OECD, indicating they are ranging from 0.32 to 0.53, and η_1 is in this interval. We take the lowest industry value-added rate from China's 2007 Input-Output Table as η_2, equaling 0.15. In the mathematical simulation, we take θ, showing the depth of export processing, as $\theta_1 = 0.1$, $\theta_2 = 1$, $\theta_3 = 10$ separately，the smaller θ is, the greater depth of the export processing.

Figure 3 illustrates the same facts as figure 2 does simplify continuum-of-firms to two firms, η_1 and η_2, corresponding to the complete homemade sector and export processing one in reality, respectively. Alternatively, there is a notable difference in these 3 figures, that is, the curve grows steeper with the decreasing of export processing depth. When λ equals one, suggesting all of the intermediate goods are imported, Industry value-added rate is the lowest, all of which reaching

0.15 simultaneously, When λ equals zero, suggesting all of the intermediate goods are produced domestically, Industry value-added rate is the highest, reaching 0.17, 0.28 and 0.37 respectively, as shown in Figure 3. The greater the export processing depth is, the lower the maximum Industry value-added rate is. As a result, the corresponding curve is more gentle.



a. θ is 0.1 **b. θ is 1** **c. θ is 10**

Figure 3 value-added rate and foreign intermediate goods share with different θ

We also find that the scope of export processing, which is illustrated as foreign intermediate goods share, is another factor negatively influencing industry value-added rate. The wider the scope, the lower the Industry value-added rate is. Such a negative correlation is exacerbated by the depth of export processing, because the deeper export processing requires more foreign intermediate goods and the value-added rate turns smaller in response.

4. Conclusions

In this paper, we propose a model in which vertical specialization could explain China's low Industry value-added rate. We illustrate the main forces using a three-stage, two-country Ricardian model of trade, in which there is a constant elasticity of substitution between the intermediate goods and primary ones. The intermediate goods are produced using Cobb-Douglas production technology while the primary goods using the constant elasticity of substitution production technology. The intermediate goods and primary goods can be traded freely, and vertical specialization occurs when countries focus on one particular stage of good's production rather than on the complete stages.

The main contribution of this paper is theoretical, demonstrating that the vertical specialization will lead to low Industry value-added rate through importing intermediate goods, even though value-added rate of single sector is not changed. Vertical specialization occurs as long as there exists comparative advantage, and production will transform from countries with higher costs to countries with lower costs, while these industries all are low value-added rate. This process increases the primary good share of industries, thus decreases the Industry value-added rate. Our findings are similar to Liu's(2011) conclusion that the declining trend of value-added rate is related to the increasing share of intermediate goods imported from aboard. The following model simulation shows that industry value -added rate is also negatively affected by the scope of export processing, which could be expressed as the foreign intermediate goods share, and the negative correlation is exacerbated by the depth of export processing.

From above, we conclude that China's low industry value-added rate roots in low factor price. It is difficult to change due to vertical specialization depriving China of pricing power in intermediate and primary goods. Consequently, it's an urgent task for China to strive for pricing power in the world market and boost domestic technology innovation. Only in this way can China turn form a big industrial nation to a powerful one.

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