A Specific-factor Model of Offshoring

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Abstract: This paper presents a specific factor model of a small open economy to show the factor price effect and welfare effect of offshoring. Different to ambiguous wage effect conclusions of offshoring under Heckscher-Ohlin framework, the conclusions of this paper is clear-cut. Offshoring will benefit specific factor (skilled labour and land), hurts some non-specific factor (unskilled labour), and enlarge the skilled and unskilled wage gap in home country. This conclusion is independent of factor intensity of offshoring fragment, complete or incomplete specialization at equilibrium and whether *FDI* is included. However, a welfare loss of home country after offshoring might be possible either with or without *FDI* because of the redistribution of incomes to different factor owners. If certain amount of unskilled labour is trained to update skills, changes of factor prices are depending on the pre-training equilibrium, international capital mobility and capital intensity of fragments.

Key words: Offshoring Specific Factor Model Factor price effect Welfare effect

JEL Classification: F11 F16

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1. Introduction

Since the 1970s, the phenomenon of a rising trend of wage gap between skilled and unskilled labour has becomes common both in developed and developing countries. This issue attracts a series of theoretical and empirical studies on the mechanism behind. Recently, a wave of studies focused on international trade in intermediate helps to explain the major reason of the wage inequality, besides technological progress and international trade from low wage developing countries.

Arndt (1997) develops a 2×2×2 model under conventional Heckscher-Ohlin trade model, and shows that offshoring may increase, rather than decrease, employment by creating more jobs in the remaining activities. Offshoring by labour-intensive importable industries will raise both employment and wages, which is good news to the workers. Feenstra and Hanson (1996) tell a story about fragmentation between USA and Mexico, in which labour is treated differently as skilled labour and unskilled labour. Wage inequality will be enlarged in both countries if USA outsources the least unskilled intensive component, but from the Mexico's point of view, it is the most skilled intensive. They argue that rising wage inequality in Mexico is linked to capital inflows from abroad, which corresponds to an increase in offshoring by multinationals and shifts production in Mexico towards relatively skill-intensive goods, therefore increases the relative demand for skilled labour. Jones and Kiezkowski (2000) continue the analysis by expanding Arndt (1997) to a model of multi-goods 2- inputs. In their model, if a country loses the labour-intensive segment, the wage rate need not fall, dependent on whether the country's factor endowment proportion is greater than either segment, or less than either segment, or lies within the core of diversification of the fragmented process. However, most of the works of offshoring based on the Heckscher-Ohlin framework got ambiguousness of conclusions in terms of wage effects of offshoring, which makes relevant policy even harder in practice.

This paper is trying to explain the impact of offshoring from an alternative view: the specific factor model, and trying to show whether the factor price effect and welfare effect of offshoring in specific factor model is robust. I present a general equilibrium model of two countries with perfect competitive industry *X* and *Y.* The final goods *X* is produced by land and unskilled labour, and the final good *Y* is assembled by the fragment *N* and *M*. Only fragment *N* can be offshored to a lower cost production location. Land and skilled labour are specific factors to each industry, while unskilled labour and capital are mobile between industries or sectors. The factor price effect and welfare effect of offshoring can be shown by comparative statics analysis by comparing the post-offshoring factor prices and welfare with the pre-offshoring equilibrium. Not surprisingly, relative wage gap between skilled and unskilled labour will increase after offshoring, independent of factor intensity of offshoring fragments, international physical capital mobility, and specialization degree at the equilibrium. The conclusion of factor price effect of offshoring is more robust than that in *H-O* framework, and more normal sounding to explain the real world. But the welfare after offshoring might be worsened because of the redistribution of incomes to different factor owners.

Among very few works on offshoring based in the specific factor framework, Kohler (2001 and 2004) presents an international fragmentation model based on the specific factor framework with 2 final-goods 2 intermediate-goods 3 factors. However, my model is the first one to explain offshoring with factor specificity in a standard mathematic way, as far as I know. Another feature of my model is that the labours are treated as skilled and unskilled labour according to its skill and specificity. International capital mobility is highlighted here to show whether the factor mobility is crucial to the impact of offshoring on factor price and welfare.

Analyzing offshoring under specific factor framework is both of theoretical importance and practical significance. In the real world, economy's response to exogenous disturbance may not cause an adjustment of factor reallocation, if factors are specific to the industry, such as some kind of physical capitals and human capitals. Steven et al (1998) shows that the magnitude of gross job flows falls sharply with the relative level of plant wages, and high level of specific human capital with high wages implies greater durability in the employment relationship, which means that higher-wage workers are more specific to an industry comparing to lower-wage workers. Why not take the skilled labour as a specific factor in an industry to investigate the effect of offshoring? Obviously, researchers or designers, after years of education and training, are more professional and stickier to a company, rather than cleaner or housekeeper.

The rest of my paper is organized as follows. In Section 2 we first show the equilibrium of an open economy without offshoring, and then talk about the equilibrium after offshoring with international factor mobility (in term of *FDI*) and without international factor mobility. We compare the welfare of home country before and after offshoring in Section 3 and extend the model to consider the unskilled labour training for skilled labour in Section 4. Section 5 concludes.

2. Basic Model

We first focus on the equilibrium of small open economy without offshoring, and then compare the equilibrium under offshoring with and without *FDI* to it. We keep the assumption of specific factor model and try to identify the factor price effect and welfare effect.

2.1 Equilibrium before offshoring

As the standard specific factor model, there are two final goods, agricultural product X and industrial product Y, in a perfect competitive open market in country H facing given world prices. X is produced by land T and unskilled labour L, but Y is assembled by intermediate N and M without further cost. M has more technology content than N, as we need unskilled labour L and capital K to produce N, and capital K and skilled labour S to produce M. Land T is a specific factor to industry X, and skilled labour S is a specific factor to sector M in industry Y. The nonspecific unskilled labour L moves between industry X and Y, and capital K moves between sector N and M within industry Y. Figure 1 shows the relationship of inputs and

outputs in *H*.

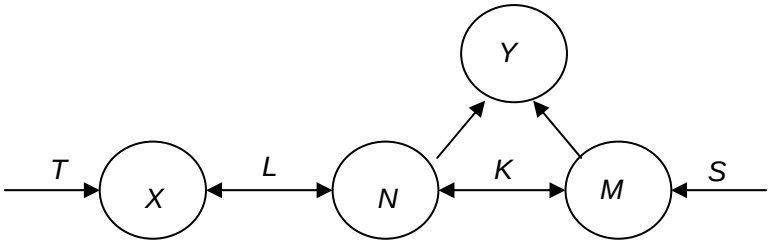

Figure 1 Inputs and Outputs in Country *H*

Here we assume that offshoring is not applicable at the moment because of production technology or country's trade policy. All the intermediates (*M* and *N*) are produced in country *H*. *T, L, K* and *S* stand for the factor endowments in country *H*, and r_T, r_L, r_K and r_S stand for the price of each factor. The production functions for *X, Y, N, M* in *H* are Cobb-Douglas function, as shown below[2]:

$$Q^X = f^X(T, L),$$

$$Q^Y = f^Y(Q^N, Q^M), Q^N = f^N(L, K), Q^M = f^M(K, S)$$

Let the price of *X* equal to 1, and the price of *Y* equal to p. Given Cobb-Douglasr production function of *Y*, $p \times f^Y_{Q^N}$ and $p \times f^Y_{Q^M}$ can be taken as imputed prices of fragments *N* and *M*, p_N .and p_M. If a_{ij} represents the quantity of factor *i* required per unit output of goods *j*, the basic competitive equilibrium without offshoring is determined by the following conditions:

Factor market clearing conditions in *H*:

$$a_{TX}Q^X = T, \quad (1)$$

$$a_{SM}Q^M = S, \quad (2)$$

$$a_{LX}Q^X + a_{LN}Q^N = L, \quad (3)$$

$$a_{KN}Q^N + a_{KM}Q^M = K. \quad (4)$$

Zero profit conditions of firms in *H*:

[2] Here Superscript means sector *X, N, M* or *Y.*

$$a_{TX} r_T + a_{LX} r_L = 1, \tag{5}$$

$$a_{LN} r_L + a_{KN} r_K = p_N, \tag{6}$$

$$a_{KM} r_K + a_{SM} r_S = p_M, \tag{7}$$

$$a_{NY} p_N + a_{MY} p_M = p, \tag{8}$$

The exogenous variables are relative product price *p*, factor endowments T, L, S, K and techniques of production. So eqs. (1)-(7) could be taken to represent all the equilibrium relationships for a competitive economy. Competition ensures that unit costs are minimized, and each a_{ij} depends upon the ratio of factor prices in sector or industry *j*, as shown below:

$$a_{ij} = a_{ij}(\frac{r_i}{r_p}),$$

Solve eqs. (1)(2) for each Q^j and substitute into eqs (3)(4) to obtain eq.(9):

$$\frac{L - \frac{a_{LX}}{a_{TX}} T}{a_{LN}} = \frac{K - \frac{a_{KM}}{a_{SM}} S}{a_{KN}}. \tag{9}$$

Since the a_{ij} depend on factor prices, eqs (5)-(9) provide a set of four relationships in the four factor prices and exogenous parameters of commodity prices and factor endowments. Consequently, the factor prices could be found at the equilibrium before offshoring. So are the outputs.

The direct effect of offshoring is to reduce the unit cost of offshoring component. The story is best reveal by considering the way in which the equilibrium is disturbed by arbitrary changes in one component price (also changes in factor endowment if offshoring takes place with the company of *FDI*). We will discuss the changes of equilibrium after offshoring in the next two sections. Let's start with the case of offshoring with *FDI* first.

2.2 Offshoring With *FDI*

Now let's consider what will happen if the unskilled labour wage is lower in country *F* and offshoring is applicable. The lower cost of production in country *F* gives firms in *H* an incentive to relocate the production to a lower cost by offshoring. But the specific factor is not only specific to industry, but also specific to country,

which means land and skilled labour in home cannot be replaced by those in foreign. Therefore, only intermediate product *N* can be outsourced.

We further assume that firms prefer establishing an affiliate with *FDI* rather than arm-length transaction because of better ownership and management system. In order to make the analysis simple and delete the effect of capital movement for higher rent, we assume that capital price in domestic and foreign equals before offshoring. If unskilled labour wage in foreign is less than that in home[3]($r_L^* < r_L$), and the technology for production *N* in home and foreign are the same, then offshoring of *N* from home to foreign will happen only if

$$p_N - \left(p_N^* + c \right) > 0 \tag{10}$$

c is the transport cost of unit product *N*. If country *F* is a big economy with perfectly elastic unskilled labour supply, the effective production cost of *N*, $p_N^* + c$, is constant. The direct effect of offshoring fragment *N* to country *F* in Country *H* is to lower the production cost of *N*, and the pre-offshoring equilibrium is disturbed by a reduction in p_N. Differentiating eqs. (5), (6), (7), (8) and (9), you will get eqs. below:

$$\theta_{TX}\hat{r}_T + \theta_{LX}\hat{r}_L = 0, \tag{5'}$$

$$\theta_{LN}\hat{r}_L + \theta_{KN}\hat{r}_K = \hat{p}_N, \tag{6'}$$

$$\theta_{SM}\hat{r}_S + \theta_{KM}\hat{r}_K = \hat{p}_M, \tag{7'}$$

$$\theta_{NY}\hat{p}_N + \theta_{MY}\hat{p}_M = 0, \tag{8'}$$

$$\frac{\hat{L} + \lambda_{LX}\left(\sigma_X\left(\hat{r}_L - \hat{r}_T\right) - \hat{T}\right)}{\lambda_{LN}} = \frac{\hat{K} + \lambda_{KM}\left(\sigma_M\left(\hat{r}_K - \hat{r}_S\right) - \hat{S}\right)}{\lambda_{KN}} + \sigma_N\left(\hat{r}_K - \hat{r}_L\right). \tag{9'}$$

The '^' over a variable denotes the relative change in that variable (e.g. $\hat{r}_T$ is dr_T / r_T). The θ_{ij} refers to the cost share of factor *i* in industry *j* which is constant for Cobb-Douglas production function (e.g. θ_{TX} is $a_{TX}r_T / \left(a_{TX}r_T + a_{LX}r_L\right)$). λ_{ij} refers to the fraction of mobile factor *i* absorbed by the industry *j* (e.g. λ_{LN} is $a_{LX}Q^X / \left(a_{LX}Q^X + a_{LN}Q^N\right)$), and σ_j refers to the elasticity of substitution between

[3] We use superscript * to present variables in foreign country.

factors in industry *j* (e.g. σ_X is $\left(\hat{a}_{TX}-\hat{a}_{LX}\right)/\left(\hat{r}_L-\hat{r}_T\right)$).

If offshoring takes place in form of *FDI*, from the assumption above we know that $\hat{T}=\hat{L}=\hat{S}=0,\hat{r}_K=0$.So Solutions for factor price effect of changes in intermediate *N*'s price and capital outflow are provided in eqs.(11), (12), (13) and (14):

$$\hat{r}_L=\hat{p}_N/\theta_{LN}<\hat{p}_N<0, \tag{11}$$

$$\hat{r}_S=\hat{p}_M/\theta_{SM}>\hat{p}_M>0, \tag{12}$$

$$\hat{r}_T=-\frac{\theta_{LX}\hat{p}_N}{\theta_{TX}\theta_{LN}}>0. \tag{13}$$

$$\hat{K}=\left(\frac{\lambda_{LX}\lambda_{KN}}{\lambda_{LN}}\frac{\sigma_X}{\theta_{TX}\theta_{LN}}+\frac{\sigma_N}{\theta_{LN}}\right)\hat{p}_N+\frac{\lambda_{KM}\sigma_M}{\theta_{SM}}\hat{p}_M. \tag{14}$$

It is clear that the return for skilled labour increases more proportional than changes of imputed price of *M*, and the return for unskilled labour decrease more proportional than changes of imputed price of *N*. The return for land increase more proportional than changes of imputed price of *N* if $\theta_{LX}/\theta_{TX}\theta_{LN}>1$.This is because the changes in commodity price must be trapped between the changes in the returns to factors used to produce each commodity.

The intuition of the equilibrium behind the equations is explained with the help of Figure 2. In Figure 2.1 *GG'* and *HH'* are the demand curves for unskilled labour in sector *X* and *N*, respectively. Given the endowment of land in sector *X*, *GG'* is unique and *HH'* can move up or down for different capital used in sector *N* and different imputed price of *N*. In Figure 2.2 *MM'* and *FF'* are the demand curves for capital in sector *N* and *M*, respectively. Given the endowment of skilled labour and imputed price of *M*, *FF'* is unique and *MM'* can move up or down for different unskilled labour used in sector *N*.

If eq. (10) is satisfied, then offshoring of intermediate *N* will happen and capital in sector *N* begins to move to foreign in terms of *FDI* to produce *N*. Now firms can produce the intermediate with a lower price, which will certainly decrease the imputed price of *N* to the level of p_N^*+c, and the *HH'* in Figure 2.1 moves downward to *KK'*. Unskilled labour formerly used to produce *N* moves to nowhere but sector *X* and capital formerly used to produce *N* moves broad or to the sector *M*. Unskilled labour wage decreases and price of land increase because of the marginal revenue of land increases as more unskilled labour is used in sector *X*. As more intermediate *N* and less intermediate *M* are used to produce *Y*, it will increase the imputed price of *M*.

The skilled-labour's wage will increase as the price of the other factor capital is constant. This process is shown in Figure 2.2, where *FDI* outflow decreases the capital endowment at home, accompanied by a right shift from O_N to O_N', and the demand curve of capital in sector *N MM'* moves down to *NN'* because of the falling imputed price of *N* , and the demand curve of capital in sector *M* *FF'* move up to *EE'* because of the rising imputed price of *M*. This process will continue until the cost of producing intermediate *N* at home and abroad equals, which is $p_N' = p_N^* + c$ (superscript ' means equilibrium of offshoring with *FDI*). At the new equilibrium, point *B* in figure 2.1 and 2.2, more *X* and more intermediate *M* are produced as more factor is allocated in industry *X* and sector *M*, and the total quantity of intermediate *N* from home and abroad are increased as Q^N / Q^M is larger if p_N / p_M is smaller.

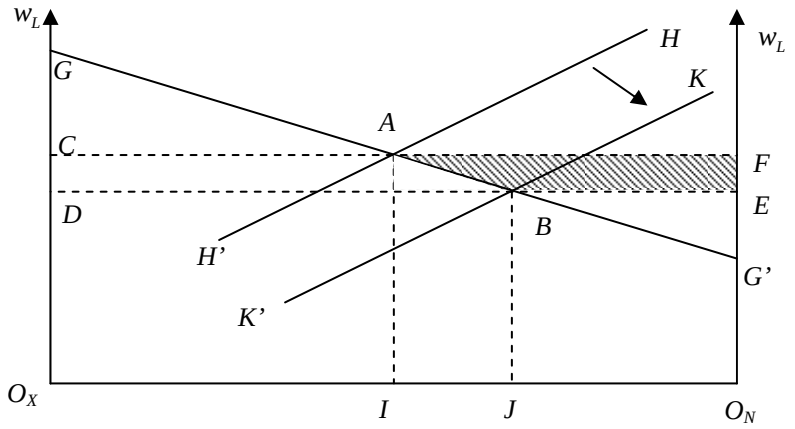

Figure 2.1 Unskilled labour distribution between sector *X* and *N*

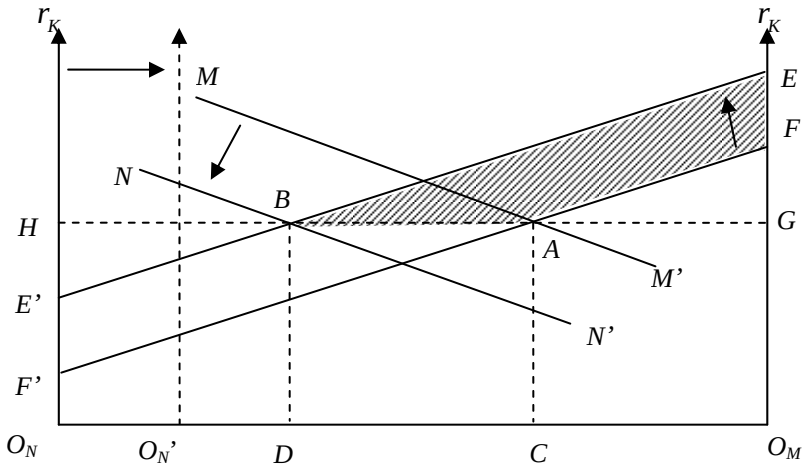

Figure 2.2 Capital distribution between sector *N* and *M*

However, it is not necessary to have such equilibrium of incomplete specialization.

If the demand curve for unskilled labour in sector *X* is very flat, it could be that when all of the unskilled labour is used to produce *X*, domestic production cost of intermediate *N* is still higher than that at foreign. Consequentially, all the intermediate *N* are outsourced to foreign and firms in *H* specialize in intermediate product *M*. At the equilibrium, consistent with equilibrium above, the price of land increases as more unskilled labour is allocated in industry *X*, and the skilled wage increase as the imputed price of intermediate *M* increases, and the unskilled wage decreases, but higher than foreign effective unskilled wage, which is $r_L^* + c/a_{LN}^*$.

Proposition One: In the specific factor model with land and skilled labour as specific factor, offshoring with FDI will drive the price of unskilled labour down, increase the price of specific factor, and enlarge the relative price of skilled-unskilled wage. This conclusion is irrelevant to factor intensity of offshoring fragments and specialization degree (complete or incomplete specialization) at equilibrium after offshoring.

Proof: See eqs. (11), (12) and (13).

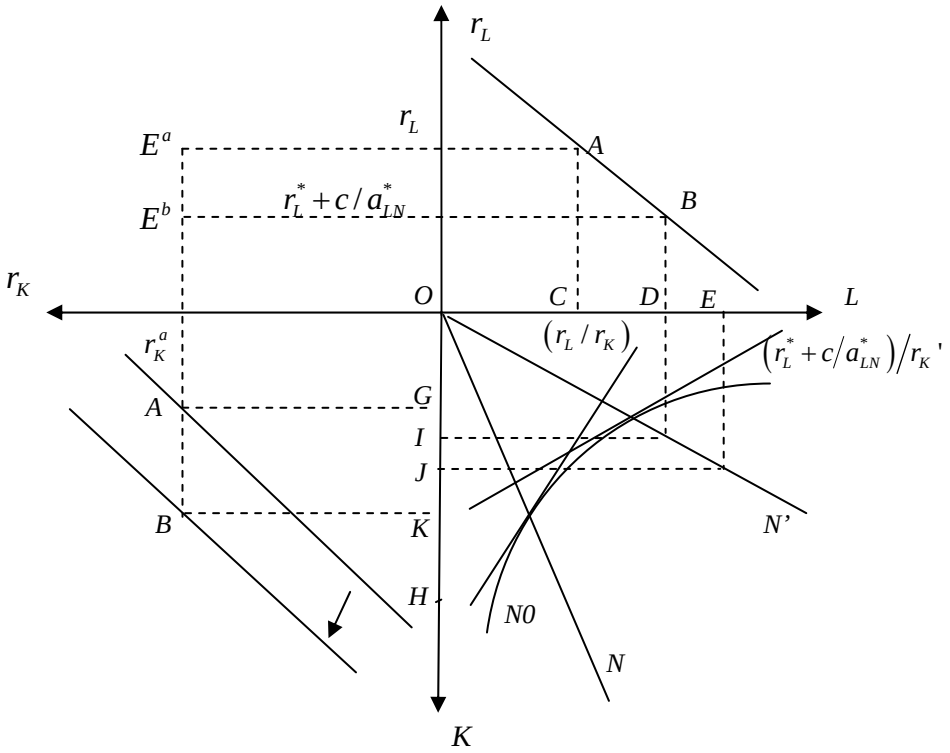

Figure 3 Equilibrium after offshoring

How much capital is moved abroad and how much unskilled labour is needed from foreign country could be illustrated by Figure 3. The upper right quadrant demonstrates unskilled labour demand in sector *X*, and *OE* is the endowment of unskilled labour L . The lower left quadrant demonstrates capital demand in sector *M*

and *OH* is the endowment of capital K. Point *A* and *B* are the equilibrium before and after offshoring. The upper left quadrant shows the equilibrium set of r_L and r_K. If eq. (10) is satisfied, the direct effect of offshoring is to decrease the production cost of *N* at home to the level of production cost at foreign with the transport cost included, Labour used in industry *X* is *OD* and labour used in sector *N* is *DE*. In the lower left quadrant, the demand curve of capital in sector *M* moves "up" as the imputed price of *M* increases. So at the new equilibrium, capital used in sector *M* is *OK* while capital used in sector *N* is *KH*. Now we need the isoquant of *N* illustrated in the lower right quadrant. N_0 is the isoquant of intermediate *N* at the after-offshoring equilibrium price $p_N^* + c$. Given homogenous production function of *N*, *ON* is the capital-unskilled labour ratio at the factor price before offshoring. As the relative price of unskilled labour over capital decreases, the capital-unskilled labour ratio moves towards unskilled labour, shown as *ON'*. Given domestic equilibrium factor price after offshoring (r_K and $r_L^* + c / a_{LN}^*$) and the amount of unskilled labour used in sector *N* (shown as *DE*), we know that the amount of capital used in sector *N* at country *H* is *IJ* in figure 3, and investment to foreign country is *KH-IJ* in figure 3. Similarly, we will know the amount of unskilled labour needed from foreign country once we have known the relative factor price r_L^* / r_K in country *F* and capital investment.

2.3 Offshoring Without *FDI*

Now let's consider another situation of offshoring if capital cannot move internationally. We keep other assumptions from above that unskilled wage at country *H* is greater than that in country *F* and capital price equals before offshoring. Country *F* is a large economy with perfect elasticity of supply of capital and unskilled labour, which means the production cost of intermediate *N* is constant in country *F*. Given a set of factor price in country *F*, the cost as well as imputed price (p_N^*) is less than imputed price in country *H* (p_N) before offshoring. The necessary condition that offshoring happens is still eq. (10), which is production cost at home is larger than that in foreign plus transports cost.

If firms at country *H* begin to buy intermediate *N* from foreign country and it breaks the existing equilibrium. Much similar to the case above, the direct effect of offshoring is to reduce the production cost of intermediate *N* at country *H* to the level of $p_N^* + c$, which will increase the imputed price of intermediate *M* to keep the price of *Y* unchanged. But now capital cannot move internationally. Knowing $\hat{T} = \hat{L} = \hat{S} = \hat{K} = 0,$ we will get the changes of factor prices by solving (5'), (6'), (7') and (8') all together.

$$\hat{r}_L = \Delta\hat{p}_N < 0, \tag{11'}$$

$$\hat{r}_T = -\frac{\theta_{LX}}{\theta_{TX}}\Delta\hat{p}_N > 0. \tag{12'}$$

$$\hat{r}_S = \Phi\hat{p}_M > 0, \tag{13'}$$

$$\hat{r}_K = \frac{\hat{p}_M - \theta_{SM}\hat{r}_S}{\theta_{KM}} \tag{14'}$$

Where $\Delta = \dfrac{\dfrac{\lambda_{KM}\sigma_M}{\lambda_{KN}}\left(\dfrac{1}{\theta_{KN}} + \dfrac{\theta_{NY}}{\theta_{MY}\theta_{SM}}\right) + \dfrac{\sigma_N}{\theta_{KN}}}{\dfrac{\lambda_{LX}}{\lambda_{LN}}\dfrac{\sigma_X}{\theta_{TX}} + \dfrac{\lambda_{KM}}{\lambda_{KN}}\dfrac{\theta_{LN}}{\theta_{KN}}\dfrac{\sigma_M}{\theta_{SM}} + \dfrac{\sigma_N}{\theta_{KN}}}$,

$$\Phi = \frac{\left(\dfrac{\lambda_{LX}\sigma_X}{\lambda_{LN}\theta_{LN}\theta_{TX}} + \dfrac{\sigma_N}{\theta_{LN}}\right)\dfrac{\theta_{MY}}{\theta_{NY}} + \left(\dfrac{\lambda_{KM}\sigma_M}{\lambda_{KN}} + \dfrac{\lambda_{LX}\theta_{KN}\sigma_X}{\lambda_{LN}\theta_{LN}\theta_{TX}} + \dfrac{\sigma_N}{\theta_{LN}}\right)\dfrac{1}{\theta_{KM}}}{\dfrac{\lambda_{LX}\theta_{SM}\theta_{KN}\sigma_X}{\lambda_{LN}\theta_{KM}\theta_{LN}\theta_{TX}} + \dfrac{\theta_{SM}\sigma_N}{\theta_{KM}\theta_{LN}} + \dfrac{\lambda_{KM}\sigma_M}{\lambda_{KN}\theta_{KM}}}.$$

It is clear that the returns for land and skilled-labour will increase and return for unskilled-labour will decrease. There will be a magnification effect of unskilled (or skilled) labour if $\Delta > 1$ (or $\Phi > 1$). A magnification effect of land may exist if $\Delta > \dfrac{\theta_{LX}}{\theta_{TX}}$. The price of capital may go up (or down) depends on $\theta_{SM}\Phi < (or >) 1$. If there isn't a magnification effect of skilled labour, the price of capital will increase.

The intuition of the equilibrium behind is similar to the above. After offshoring, unskilled labour which is used to produce *N* moves to industry *X* and increases the price of land at the expense of decreasing unskilled wage. Capital which is used to produce *N* moves nowhere but sector *M* and skilled wage increase by the joint force of rising imputed price *M* and inflowing more capital. Now it is hard to tell the changes of capital price. As shown in figure 2.2, a reduction of imputed price of *N* will move the demand curve for capital in sector *N* down and a increase of imputed price of *M* will move the demand curve for capital in sector *M* up, but it is not necessary to keep the new intersection point at point *B*, which depends on the income effect and substitute effect.

As illustrated in figure 4, *M0* is the isoquant of intermediate *M* before offshoring. An increase in the imputed price of *M* shift the isoquant inward and the price of skilled labour and capital will increase at the same proportion if the capital-skilled labour ratio is unchanged, called income effect. However, this is not stable as more

capital is attracted to sector *M* because of higher rent. Skilled labour is replaced by a cheaper capital so the capital-skilled labour ratio is increased and the relative capital-skilled labour return is decreased, called substitution effect. The skilled wage goes up definitely while the capital price is determined which effect is stronger.

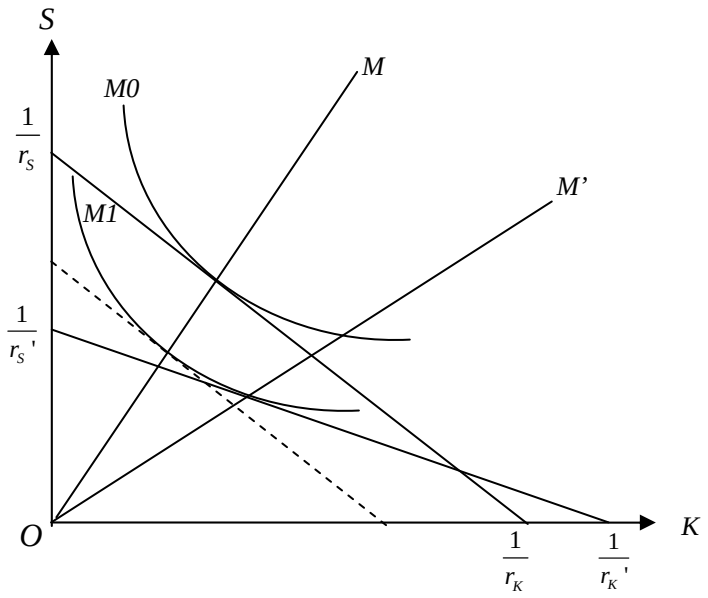

Figure 4 Capital price changes after offshoring

Again, it is not necessary to have such an incomplete specialization of equilibrium. If the demand curve for unskilled labour in sector *X* is very flat as *GG'* in figure 2.1, it could be that when all of the unskilled labour is used to produce *X* domestic production cost of *N* is still higher than foreign effective cost of *N*. Consequentially, all the intermediate *N* are outsourced to foreign and firms in country *H* specialize in intermediate product *M*. At the equilibrium, consistent with equilibrium above, the price of land increases as more unskilled labour is allocated in industry *X*, and the skilled wage increase as both the imputed price of intermediate *M* and capital used in sector *M* increase. Unskilled wage decreases and the direction of capital price change is ambiguous, which depends on price effect and substitution effect.

Proposition Two: In the specific factor model with land and skilled labour as the specific factor, offshoring without international factor mobility will increase the price of specific factors, decrease the price of unskilled labour, and enlarge the gap between skilled and unskilled labour. The price of capital may go up or down, depending on the income effect and substitute effect of a rise in imputed price of M. This conclusion is irrelevant to relative factor intensity of fragments and specialization degree at equilibrium.

Proof: See (10'), (11'), (12') and (13').

Table 1 summarizes the changes of factor prices and outputs after offshoring with

and without *FDI*. ↑, ↓,---,? denotes increase,decrese, no changeness and unknown. For the case of offshoring with *FDI*, specifi factor gains from offshoring and nonspecific factor unskilled labor (capital) loses (don't change) from offshoring. For the case of offshoring without *FDI*, specific factor also gains from offshoring and nonspecific factor unskilled labor also loses from offshoring, but the changes of captial price is uncertain dependent on price effect and subsitution effect. It is clear that output of each indusrty and relatvie wage of skilled and unskilled labor increase in both cases, which is irrevalant to factor intensity, specializatrion degree at equlibrium and captial intermational mobility.

Table 1 Changes of factor prices and outputs after offshoring

Factor price or output	r_T	w_L	r_K	w_S	$\frac{w_S}{w_L}$	Q^X	Q^M	Q^Y
Offshoring With *FDI*	↑	↓	--	↑	↑	↑	↑	↑
Offshoring Without *FDI*	↑	↓	?	↑	↑	↑	↑	↑

↑ ↓ -- ? denote an increase, an decreas, unchange and unsureness.

3. Welfare Effect Of Offshoring

Although the conclusion of factor price effect of offshoring in *H-O* framework hasn't reached an agreement, the positive effect of offshoring on welfare is accepted widely. Dose the welfare gain from offshoring in specific factor model? Let's resort to the familiar "calculus of areas" if the welfare of a country is defined as the national income for factor owners. From last chapter we know that the income for unskilled labour is shrinking, and the income for land owners and skilled labour is increasing. The income for capital owners is unchanged in the case of offshoring with *FDI* as it gets the same return in home and abroad, or uncertain in the case of offshoring without *FDI*. So the overall change of welfare at home is calculated by the changes of all the incomes for each factor.

Take the case of offshoring with foreign direct investment by Figure 2.1 and Figure 2.2.as an example[4]. Suppose point *A* and *B* is the equilibriums before and after offshoring. In Figure 2.1, area *GAC* measures the income of land owners before offshoring and area CO_XO_NF measures the income of unskilled labour. Area *CABD*

[4] The explanation of welfare after offshoring without *FDI* is similar to that with *FDI*, except for the returns for capital. Land owners and skilled labour gain, and unskilled labour lose after offshoring. Because the change of capital rental is dependent on income and substitute effect, it is hard to tell whether capital owners gain. This process could be draw in figures as well.

measures the additional income obtained by land owners after offshoring, and the income of unskilled labour is lost by the area *CDEF* after offshoring. The net loss of incomes for land owners and unskilled labour is shown clearly in the shadow area *ABFE* in Figure 2.1. Moreover, in Figure 2.2, the income obtained by skilled labour increases from area *GAF* to the area *GEB* after offshoring, and income of capital is unchanged as the area $HGO_M O_N$. So the net gain of capital owners and skilled labour is measured by shadow area *BAFE*. However, It is not clear to tell the overall welfare of home country after offshoring in specific factor model which is area *BAFE* minus area *ABFE*, but at least we know that the specific factor gains and the industrially mobile factor, unskilled labour, loses. Welfare of home country is more likely to lose after offshoring if the difference of unskilled labour wage between countries is larger, or the imputed price of *M* increase less for a given reduction of the imputed price of *N*, which means a smaller θ_{NY}/θ_{MY} from eq. (8). Because unskilled labour loses more if the unskilled wage equality between countries are larger and skilled labour gains less from a smaller rise of imputed price of *M*.

It is worth trying to show the welfare in a mathematics way and relate the changes of welfare to the parameters we have. The changes of welfare are measured by the changes of incomes obtained by factor owners by eq. (15)

$$dW = dr_T * T + dr_L * L + dr_K * K + dr_S * S \tag{15}$$

Or equivalently,

$$\hat{W} = \hat{r}_T \theta_{TW} + \hat{r}_L \theta_{LW} + \hat{r}_K \theta_{KW} + \hat{r}_S \theta_{SW} \tag{15'}$$

where θ_{iW} is the income share of factor *i* in welfare before offshoring.

Eq. (16) is the relative changes of welfare for the case of offshoring with *FDI* by taking $dr_K = 0$ and eqs. (11)-(13) back to eq. (15')

$$\hat{W} = \left(-\frac{\theta_{LX}}{\theta_{TX}\theta_{LN}}\theta_{TW} - \frac{\theta_{NY}}{\theta_{SM}\theta_{MY}}\theta_{SW} + \frac{\theta_{LW}}{\theta_{LN}} \right) \hat{p}_N . \tag{16}$$

And home country's welfare will be worsened after offshoring if

$$\frac{\theta_{LW}}{\theta_{LN}} - \frac{\theta_{LX}\theta_{TW}}{\theta_{TX}\theta_{LN}} - \frac{\theta_{NY}\theta_{SW}}{\theta_{SM}\theta_{MY}} > 0 \tag{16'}$$

Eq. (17) is the relative changes of welfare for the case of offshoring with *FDI* by taking eqs. (11')-(14') back to eq. (15').

$$\hat{W} = \left(\left(\theta_{LW} - \frac{\theta_{LX}}{\theta_{TX}} \theta_{TW} \right) \Delta + \left(1 + \frac{\theta_{KW}}{\theta_{KM}} \right) \frac{\theta_{SM} \theta_{NY} \Phi}{\theta_{MY}} - \frac{\theta_{NY} \theta_{KW}}{\theta_{KM} \theta_{MY}} \right) \hat{p}_N . \tag{17}$$

Home country's welfare will be worsened after offshoring if

$$\left(\theta_{LW} - \frac{\theta_{LX}}{\theta_{TX}} \theta_{TW} \right) \Delta + \left(1 + \frac{\theta_{KW}}{\theta_{KM}} \right) \frac{\theta_{SM} \theta_{NY} \Phi}{\theta_{MY}} > \frac{\theta_{NY} \theta_{KW}}{\theta_{KM} \theta_{MY}} \tag{17'}$$

Proposition Three: The welfare of home country might be worsened after offshoring with or without FDI, if inequality (16) or (16') is satisfied.

Proof: See (16), (16'), (17) and (17')

4. Unskilled Labour Training

There is a chance to get educated. Suppose some of the unskilled labour can be trained to equivalent skilled labour. The cost is so small that we can ignore it. What's the effect of labour endowment change on factor returns? The answer is not as simple as above. We take the equilibrium after offshoring with and without *FDI* but before labour training as the benchmark, and compare the changes of factor prices and outputs after training with it.

The supply of unskilled labour is less and skilled labour more after unskilled labour training. So we have $\hat{T} = 0,\ \hat{L} < 0,\ \hat{S} > 0, \hat{r}_K = 0$ for the case of offshoring with *FDI*, and $\hat{T} = \hat{K} = 0, \hat{L} < 0, \hat{S} > 0$ for the case of offshoring without *FDI*. Let's go back to eqs. (5'), (6'), (7'), (8') and (9'), and the equilibrium with *FDI* is shown by eqs. (17)-(20) below:

$$\hat{r}_L{}' = \hat{p}_N / \theta_{LN} < \hat{p}_N < 0, \tag{17}$$

$$\hat{r}_S{}' = \hat{p}_M / \theta_{SM} > \hat{p}_M > 0, \tag{18}$$

$$\hat{r}_T{}' = -\frac{\theta_{LX} \hat{p}_N}{\theta_{TX} \theta_{LN}} > 0, \tag{19}$$

$$\hat{K}' = \left(\frac{\lambda_{LX} \lambda_{KN}}{\lambda_{LN}} \frac{\sigma_X}{\theta_{TX} \theta_{LN}} + \frac{\sigma_N}{\theta_{LN}} \right) \hat{p}_N + \frac{\lambda_{KM} \sigma_M}{\theta_{SM}} \hat{p}_M + \frac{\lambda_{KM} \hat{S}}{\lambda_{KN}} + \frac{\hat{L}}{\lambda_{LN}}. \tag{20}$$

LEMMA 1 : ***If offshoring is in the form of FDI, unskilled labour training have no effect on equilibrium factor price. The welfare of home country is better after***

labour training.

Proof: eqs (17), (18), (19) are exactly same to (11), (12), (13), respectively.

From eq. (15), we know $\frac{d\hat{W}}{d\theta_{SW}} = -\frac{\theta_{NY}}{\theta_{SM}\theta_{MY}}\hat{p}_N > 0, \frac{d\hat{W}}{d\theta_{LW}} = \frac{\hat{p}_N}{\theta_{LN}} < 0.$ So $d\hat{W} > 0$ when $d\theta_{SW} > 0$ and $d\theta_{LW} < 0$.

The international mobility of capital will make sure that the rent of capital will not change, which will not only keep the wage of skilled labour unchanged as the imputed prices of intermediate *N* and *M* are unchanged, but also keep the unskilled labour unchanged because the cost of *N* at home should equal that at foreign at the equilibrium. Now, the welfare of home country is also improved as national income increase as less unskilled labour and equivalent more skilled labour are in the economy.

If the pre-training situation is without *FDI*, the equilibrium will more complicated, as shown by eqs. (17')-(20') below:

$$\hat{r}_L' = \Delta\hat{p}_N - \frac{\frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}}{\lambda_{KN}}\hat{S}}{\frac{\lambda_{LX}}{\lambda_{LN}}\frac{\sigma_X}{\theta_{TX}} + \frac{\lambda_{KM}}{\lambda_{KN}}\frac{\theta_{LN}}{\theta_{KN}}\frac{\sigma_M}{\theta_{SM}} + \frac{\sigma_N}{\theta_{KN}}} < 0, \qquad (17')$$

$$\hat{r}_T' = -\frac{\theta_{LX}}{\theta_{TX}}\hat{r}_L > 0. \qquad (18')$$

$$\hat{r}_S' = \Phi\hat{p}_M - \frac{\frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}}{\lambda_{KN}}\hat{S}}{\frac{\lambda_{LX}\theta_{SM}\theta_{KN}\sigma_X}{\lambda_{LN}\theta_{KM}\theta_{LN}\theta_{TX}} + \frac{\theta_{SM}\sigma_N}{\theta_{KM}\theta_{LN}} + \frac{\lambda_{KM}\sigma_M}{\lambda_{KN}\theta_{KM}}} > 0, \qquad (19')$$

$$\hat{r}_K' = \frac{\hat{p}_M - \theta_{SM}\hat{r}_S}{\theta_{KM}} \qquad (20')$$

Where $\Delta = \frac{\frac{\lambda_{KM}\sigma_M}{\lambda_{KN}}\left(\frac{1}{\theta_{KN}} + \frac{\theta_{NY}}{\theta_{MY}\theta_{SM}}\right) + \frac{\sigma_N}{\theta_{KN}}}{\frac{\lambda_{LX}}{\lambda_{LN}}\frac{\sigma_X}{\theta_{TX}} + \frac{\lambda_{KM}}{\lambda_{KN}}\frac{\theta_{LN}}{\theta_{KN}}\frac{\sigma_M}{\theta_{SM}} + \frac{\sigma_N}{\theta_{KN}}},$

$$\Phi = \frac{\left(\frac{\lambda_{LX}\sigma_X}{\lambda_{LN}\theta_{LN}\theta_{TX}} + \frac{\sigma_N}{\theta_{LN}}\right)\frac{\theta_{MY}}{\theta_{NY}} + \left(\frac{\lambda_{KM}\sigma_M}{\lambda_{KN}} + \frac{\lambda_{LX}\theta_{KN}\sigma_X}{\lambda_{LN}\theta_{LN}\theta_{TX}} + \frac{\sigma_N}{\theta_{LN}}\right)\frac{1}{\theta_{KM}}}{\frac{\lambda_{LX}\theta_{SM}\theta_{KN}\sigma_X}{\lambda_{LN}\theta_{KM}\theta_{LN}\theta_{TX}} + \frac{\theta_{SM}\sigma_N}{\theta_{KM}\theta_{LN}} + \frac{\lambda_{KM}\sigma_M}{\lambda_{KN}\theta_{KM}}}.$$

LEMMA 2: ***If there is no international factor mobility, unskilled labour training for equivalent skilled labour will make the unskilled labour wage decrease more (or less), the skilled labour wage increase less (or more), the return for land increase more (or less), and the return for capital improved (worsened) if the skilled-labour capital ratio in sector M is less (or greater) than unskilled-labour capital ratio in sector N.***

Proof: If the unskilled labour becomes equivalent skilled labour after training, we have $dL = -dS < 0$ and $\frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}}{\lambda_{KN}}\hat{S} = \left(\frac{1}{\lambda_{LN}L} - \frac{\lambda_{KM}}{\lambda_{KN}S}\right)dL$ .If the skilled-labour capital ratio in sector *M* is less than unskilled-labour capital ratio in sector *N*, we have $\frac{S}{K\lambda_{KM}} < \frac{L\lambda_{LN}}{\lambda_{KN}K}$, which means $\frac{1}{\lambda_{LN}L} - \frac{\lambda_{KM}}{\lambda_{KN}S} < 0$ and $\frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}}{\lambda_{KN}}\hat{S} > 0$.

From eq. (11')-(14') and (17')-(20'), we know $\hat{r}_L' < \hat{r}_L < 0$, $0 < \hat{r}_S' < \hat{r}_S$, $0 < \hat{r}_L < \hat{r}_T'$, and $\hat{r}_K' - \hat{r}_K > 0$, if $\frac{S}{K\lambda_{KM}} < \frac{L\lambda_{LN}}{\lambda_{KN}K}$. Vice versa.

It is easy to understand the intuition behind those eqs. Let's begin with the simplest. If $\frac{S}{K^M} = \frac{L}{K^N}$, it means the capital which was used to produce *N* with unskilled labour is just enough for producing *M* with the same amount of newly trained skilled labour, given the equilibrium factor price. So factor price will not change at all. The output of *N* decreases domestically and increases abroad, and the output of *M* increases as more factors are allocated in sector *M*.

If $\frac{S}{K^M} < \frac{L}{K^N}$, it means the capital which was used to produce *N* with unskilled labour isn't enough for producing *M* with the same amount of newly trained skilled labour, given the equilibrium factor price. There is a shortage for capital, so the price of skilled labour will decrease and the price of capital will increase. But this is not a stable equilibrium because it breaks the condition that production cost of *N* in *H* and *F* equals. So price adjustment continues. At this moment, the cost of *N* in *H* is higher than that in *F*, resulting in that more *N* is outsourced. Further offshoring drives more capital go to sector *M*, which help to satisfy the exceeding demand for capital in

sector *M*, and more unskilled labour go to sector *N*, which drops the price of unskilled labour. This process will continue until that the costs of production *N* in *H* and *F* equal again. In the end, unskilled labour wage goes down as more unskilled labour is used in industry *X*, and price of goes up because the production cost in *H* equals that in *F* which is unchanged. The price of land goes up and skilled wage goes down as more skilled labour is supplied after training. It's not easy to say whether the relative wage gap goes up or down, as both unskilled and skilled labours are paid less. But we know that offshoring is reinforced.

If $\frac{S}{K^M} > \frac{L}{K^N}$, it means capital is redundant compared to trained skilled labour, and the price of skilled labour will increase and the price of capital will decrease. Now the production cost of *N* in *H* is lower than that in *F*. Offshoring will be reduced and labour used in sector *X* go back to sector *N*, which lead a rise in unskilled labour price, and capital used in sector *M* go back to *N*, which prevent capital price from declining. This process continues until that the costs of production *N* in *H* and *F* equal again. Again, it's hard to say the relative wage gap as skilled and unskilled wage goes up at the same time. But we know that offshoring is weakened.

However, we shouldn't forget the situation of Complete Specialization. If the pre-training equilibrium without *FDI* is that all the unskilled labour is employed in sector *X*, the reduction in supply of unskilled labour will leads to a rise in unskilled labour wage and a decline in factor price of land. Similarly, the increase in supply of skilled labour will lead to a decline in skilled labour wage and a rise in factor price of capital. So the relative wage gap has been narrowed. The domestic price for factors used in the production of *N* increase, which in turn reinforces the necessary condition for Complete Specialization of Offshoring. If the pre-training equilibrium offshoring is with *FDI*, analysis will be much easier. Unskilled labour training will increase the wage of unskilled labour and decrease the rent for land, just as illustrated in the case of offshoring without *FDI*. International Capital mobility will keep the capital price unchanged, which guarantees that the skilled labour wage is unchanged as well. As illustrated in Lemma 1, the overall welfare of home country will be improved as the gains for the unskilled labour can compensate the net loss in land owners.

Table 2 summarizes the changes of factor prices after labour training. Compared to the pre-training equilibrium after offshoring with *FDI*, the welfare of home country will be improved. If the pre-training equilibrium of offshoring without *FDI* is complete specialization, offshoring will be reinforced after labour training and the relative wage will decline. If the pre-training equilibrium of offshoring without *FDI* is incomplete specialization, the relative wage gap depends on relative capital/labour ratio in sector *N* and *M*.

Propostiion Four: ***If arbitary amount of unskilled labour is trained for equlivilant amount of skilled labour, chages of factor prices are dependent on pre-training eqlibrium, international capital mobility and capital intensity of fragments.***

Especially, factor prices will keep unchanged if the pre-training equliburm is Incomplete specialzation with FDI or Incomplete specialzation without FDI with same captial intensity in fragment N and M.

Proof: See table 2.

Table 2 factor price changes after labour training

Pre-training equilibrium	r_T	w_L	r_K	w_S	$\frac{w_S}{w_L}$
Offshoring without *FDI*					
Complete Specialization	↓	↑	↑	↓	↓
Incomplete Specialization					
$\frac{S}{K^M} < \frac{L}{K^N}$	↑	↓	↑	↓	?
$\frac{S}{K^M} = \frac{L}{K^N}$	--	--	--	--	--
$\frac{S}{K^M} > \frac{L}{K^N}$	↓	↑	↓	↑	?
Offshoring with *FDI*					
Complete Specialization	↓	↑	--	--	↓
Incomplete Specialization	--	--	--	--	--

↑ ↓ -- ? denote an increase, an decreas, unchangeness and unsure.

5. Concluding Remarks

Concerns about skilled and unskilled wage gap-enlarging implication and welfare-reducing implication of offshoring appear to be reasonable. By allowing skilled labour to be specific to the industry, offshoring from a small open economy will improve the gains of specific factors (land and skilled labour), and harm the industrially mobile nonspecific factor (unskilled labour). Consequentially, the relative wage between skilled and unskilled labour is increasing, and the output of each industry is expending. These conclusions are robust and irrelevant to capital mobility between countries, complete specialization or incomplete specialization at equilibrium and factor intensity of offshoring fragment. The price of capital, which moves

between sectors within an industry rather than industries, is unchanged in the case of *FDI*, or dependent on the price effect of rising imputed price of *M* and substitution effect between capital and skilled labour in the case of offshoring with an arm-length transaction. The welfare effect of offshoring in the specific factor model is not necessarily positive, if welfare is defined as the national incomes of factor owners. The overall welfare gains is measured by area *BAFE* in figure 2.2 minus area *ABFE* in figure 2.1, and welfare could be worsened after offshoring more likely if the difference of unskilled wage between home is larger or imputed price of *M* increases less given a reduction in imputed price of *N*.

The aim of this work is to show whether the factor price effect of offshoring in specific factor model is robust. Not surprisingly, conclusion here is more robust than that in *H-O* framework which depends on factor intensity of offshoring fragment, and also more robust than Kohler (2001) whose conclusion is also from a specific framework that wage will decrease if offshoring takes place with *FDI* or labour-intensive fragment is outsourced without *FDI*. In contrast to Kohler (2001), equilibrium of offshoring could be complete specialization or incomplete specialization both with *FDI* and without *FDI*, dependent on the unskilled wage gap between countries and the slope of unskilled labour demand curve in industry *X*.

The mechanism behind the model is consistent with Grossman and Rossi-Hansberg (2008). They illustrate 3 different effect of offshoring, which is relative-price effect, productivity effect and input-supply effect. In our paper, firstly we assume that country *H* is a small economy facing given world price, but there is actually relative price effect in our paper. Lowering the cost of offshoring fragment *N* increases the imputed price of another fragment *M*, as the final goods price of *Y* is given by the world market. The rise in the price of fragment *M* benefits its specific factor, while the decline in the price of fragment *N* harms the unskilled labour. Secondly, firms in *H* outsource fragment *N* to a lower cost location and improve their efficiency. Factor price changes after offshoring, acting like a sector-biased technology change. Finally, after offshoring, unskilled labour and capital which are formerly used for producing *N* need to be absorbed by other sectors to clear the factor market. Factor price changes because of the changes of factor used in each sector, which is called input supply effect.

This paper also investigates the effect of factor endowment changes on factor prices. If certain amount of unskilled labour becomes equivalent skilled labour after training and education, the situation of unskilled labour may not be better which depends on pre-training equilibrium, international capital mobility and capital intensity of fragments. If the pre-training equilibrium is complete specialization of offshoring, then we know the skilled-unskilled wage gap will be narrowed, as well expected. If the pre-training equilibrium is incomplete specialization, the skilled-unskilled wage gap depends on the relative capital/labour ratio in each intermediate product in the case of offshoring without *FDI*, or is constant in the case of offshoring with *FDI*.

Even if the final goods price is affected after offshoring, let’s say a reduction in *p*, the conclusions above can be held as well under certain conditions, because the

changes of factor prices are according to the changes of imputed price of N and M. So as long as the imputed price of N decreases and the imputed price of M increases (it should be less in present of a reduction in p) after offshoring, the skilled labour and land owner will always gain while the unskilled labour lose, and the welfare of home country may be worsened. However, things will be different if the imputed price of M decreases as well. More works will be focused on this extension later.

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