

## Factor Mobility and Wage Inequality

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### **Abstract**

This paper provides a model and conditions with which an inflow of all factors could produce wage inequality in favor of skilled labor. We show that: i) the elasticity of wage inequality with respect to factor mobility plays a key role in determining wage inequality, ii) the degree of factor mobility is crucial in producing wage inequality in favor of skilled labor in the US, and iii) conventional wisdom of the wage gap fails to hold when capital is mobile.

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## **1. Introduction**

Recently, wage inequality between highly educated (skilled) and less educated (unskilled) labor in the developed nations of Europe and North America has become more pronounced. The drastic increase in wage inequality in the US since the 1980s has become a subject of controversy among trade and labor theorists that has been highlighted by theoretical and empirical papers such as Autor, Katz, and Krueger (1998), Bhagwati and Kostos (1994), Bound and Johnson (1992), Davis (1998), Deardorff (2000), Krugman (2000), Tokarick (2005), Xu (2001) and Zhu (2004) which have speculated on the causes and their effects. The empirical studies point out that the most noteworthy development in the US labor market during the past decade has been the rise of skilled workers wages vis-à-vis those workers with lower skill endowments. Seminal papers by Feenstra (2000) as well as Choi and Greenaway (2001) focused on the effects of growing integration of the world economy on wage inequality.<sup>1</sup> These studies identify two suspects as determinants of wage inequality, namely, factor or sector biased technical progress and trade expansion.

Factor mobility has emerged as a prominent feature in the world economy during the past two decades. In spite of this fact, except Feenstra and Hanson (1996) and Markusen and Venables (1997), the previous literature has left the implications of international factor mobility on wage inequality an overlooked black box nor taken up how international factor mobility affects wage inequality in developed countries.<sup>2</sup> Our purpose is to fill this void. By deriving the elasticity of wage inequality with respect to factor mobility we show how international factor mobility has influenced wage inequality and when coupled with some reasonable conditions, wage inequality in favor of skilled labor is an inevitable outcome in the US which possesses the highest level of technology in the world.

The rest of this paper is organized as follows. In section 2, we set up a simple specific factor model in order to show how the inflow of all factors can produce wage inequality in favor of skilled labor. Section 3 considers the effects of factor mobility on wage inequality by employing the elasticity of wage inequality with respect to factor mobility and illustrate that this elasticity plays a key role in explaining wage inequality. In section 4, we demonstrate how capital mobility erodes the conventional wisdom of the effect of labor movement on the ever widening wage gap. Section 5 concludes the paper.

## 2. A Model with Factor Mobility

In order to focus on the effects which factor mobility has on wage inequality and the wage gap, we set up a simple model utilizing the following features. First, changes in the domestic factor supply are principally caused by the international movement of that factor. Second, a specific factor model is used to analyze the effects of changes in factor supply on factor prices under fixed commodity prices. We envision a developed economy that produces two commodities with three factors by the standard production function under the usual assumptions such as perfect competition, full employment, constant returns to scale and diminishing marginal productivity. The production side of the model of this economy with factor mobility is presented as follows:

$$c_j(w_j, r) = a_{L_j}(w_j, r)w_j + a_{K_j}(w_j, r)r = p_j, \quad (1)$$

$$\frac{\partial c_j(w_j, r)}{\partial w_j} X_j = L_j, \quad (2)$$

$$\frac{\partial c_1(w_1, r)}{\partial r} X_1 + \frac{\partial c_2(w_2, r)}{\partial r} X_2 = K, \quad (3)$$

$$\dot{L}_j = f_j(w_j - w_j^*), f_j(0) = 0, f_j'(\cdot) > 0, \quad (4)$$

$$\dot{K} = g(r - r^*), \quad g(0) = 0, \quad g'(\cdot) > 0, \quad (5)$$

$$w_j = w_j^*, \quad r = r^*, \quad (6)$$

$$p_j = p_j^*, \quad (7)$$

where,  $c_j(\cdot)$  is the unit cost function;  $p_j$  is the price of the  $j$  th commodity,  $w_1$  and  $w_2$  are the wage rate of unskilled and skilled labor respectively with  $r$  as the return to capital. The two types of labor are the specific factors and we define wage inequality as  $w_2 - w_1$ . The minimum quantity of the  $i$  th ( $i = K, L$ ) factor per unit output in the  $j$  th good is  $a_{ij}$ . The output of  $j$  th commodity is  $X_j$ . The quantity supplied of unskilled and skilled labor are  $L_1$  and  $L_2$  and that of capital is  $K$ . The factor and commodity prices in the foreign country are  $w_j^*$ ,  $r^*$ ,  $p_j^*$ . The dots denote the time derivative.

The zero profit condition is revealed in Eq (1). Eq. (2) is the full employment condition of both types of labor while Eq. (3) is the same for capital. Eqs. (4) and (5) show that any changes in factor supplies are realized through international factor movements that depend on the gaps in rewards between the two countries. Eqs.(6) and (7) are the equilibrium conditions in the factor and commodity markets. This model contains 10 equations; (1), (2), (3), (6), (7) with the same number of variables;  $p_j, w_1, w_2, r, X_1, X_2, L_1, L_2, K$ .

This model reflects two salient features. The first is that any changes in domestic factor supply will occur due to international factor movements rather than birth, education, or capital accumulation within this country. Thus we are considering the outsourcing of factors of production.<sup>3</sup> Second, in order to consider the effects of factor mobility on wage inequality and the widening wage gap, a specific factor model rather than a Heckscher-Ohlin model is employed.

The use of a specific factor model with an outsourcing of factor of production feature is justifiable. Skilled labor and unskilled labor are two different factors and it takes time and expense for unskilled labor to become skilled. Therefore, they are sector specific in the short run. Also, as the result of the globalization of the world economy, the acquisition of factors of production from foreign countries has become an easier proposition leading to increased international factor movement.

### **3. The Effects of Factor Mobility on Wage Inequality**

We provide a model where the simultaneous inflow of all factors into the US could produce wage inequality in favor of skilled labor. For this purpose, the first part of this section considers how such international factor movements affect wage inequality using the elasticity of wage inequality with respect to factor mobility.

Suppose that factors of production are free to migrate or emigrate from a country due to variances in factor rewards throughout the world. At given commodity prices, international factor movement will change commodity output and income, causing a change the demand and supply of factors and thus factor prices. This accompanies the repatriation of proceeds that in turn alter income and factor prices. In the long run, factor mobility changes commodity prices and international trade will modify commodity price and factor prices. However in order to obtain clear and strong effects of factor mobility, we assume that the commodity prices are fixed at the foreign prices. And because we are not interested in the welfare effects of factor mobility, we assume away the repatriation of proceeds<sup>4</sup>

In sections 3 - 1 to 3 - 3, a conventional approach of factor mobility is used: in which individual factors move depending on the differences in factor returns. In section 3 - 4, by gathering these analyses, we provide a condition under which a simultaneous inflow of all three factors produces the wage inequality in favor of skilled labor. Throughout the analysis we assume the following:

- i) Compared with the foreign country this country is a developed to the point to where both capital and skilled labor are abundant while it is scarce in unskilled labor is relatively scarce.
- ii) The second sector is capital intensive relative to the first sector.
- iii) Should  $\hat{w}_2 > \hat{w}_1$  ( $\hat{w}_2 < \hat{w}_1$ ), then wage inequality changes in favor of the skilled (unskilled) labor, where the hat denotes the relative change of the variables.

### 3 - 1. Unskilled Labor Inflow

Given technological homogeneity between nations, variations in factor endowments will retard the returns of capital and skilled labor while that of unskilled labor is enhanced. This situation will produce a simultaneous outflow of capital and skilled labor and an inflow of unskilled labor.

However to make the analysis clear we will examine these one at a time.

Consider a case where there is an unskilled labor inflow occurring due to  $w_1 > w_1^*$ . Assuming  $L_2$  and  $K$  fixed, from Eqs. (1) - (3), we obtain  $\hat{w}_1$ ,  $\hat{w}_2$ , and  $\hat{w}_2 - \hat{w}_1$  with the elasticity of wage inequality with respect to the inflow of unskilled labor stated as follows:

$$\hat{w}_1 = - \left( \frac{\theta_{K1}}{\theta_{L1}} \frac{\lambda_{K1}}{\Phi} \right) \hat{L}_1 < 0 \quad (8)$$

$$\hat{w}_2 = - \left( \frac{\theta_{K2}}{\theta_{L2}} \frac{\lambda_{K1}}{\Phi} \right) \hat{L}_1 < 0 \quad (9)$$

$$\hat{w}_2 - \hat{w}_1 = \left( \frac{\theta_{K1}}{\theta_{L1}} - \frac{\theta_{K2}}{\theta_{L2}} \right) \frac{\lambda_{K1}}{\Phi} \hat{L}_1 < 0, \quad (10)$$

where,  $\theta_{ij} > 0$  is the distributive share of the  $i$  th ( $i = K, L$ ) factor in the  $j$  th ( $j = 1, 2$ ) sector ( $\theta_{Kj} + \theta_{Lj} = 1$ );  $\lambda_{Kj} > 0$  is the fraction of capital used in the  $j$  th sector ( $\lambda_{K1} + \lambda_{K2} = 1$ ),

$\Phi = \left( \frac{\lambda_{K1}\sigma_1}{\theta_{L1}} + \frac{\lambda_{K2}\sigma_2}{\theta_{L2}} \right) > 0$ ,  $\sigma_j = (\hat{a}_{Kj} - \hat{a}_{Lj}) / (\hat{w}_j - \hat{r}) > 0$  is the elasticity of factor substitution in the  $j$  th sector with  $(\theta_{Kj} / \theta_{Lj})$  as the factor intensity in the value sense of the  $j$  th sector. The coefficient of  $\hat{L}_1$  in Eq. (10) is the elasticity of wage inequality with respect to the inflow of unskilled labor. This is a weighted product of the difference in the factor intensity.

Eqs. (8) - (10) produce the following results. First, an inflow of unskilled labor reduces the wage rate of both types of labor. Second, the direction of wage inequality depends on the differences in factor intensity. So concerning wage inequality, we have:

**Result 1.** *If the second sector is capital intensive, the importation of unskilled labor changes the wage inequality in favor of unskilled labor.*<sup>5</sup>

The intuitive aspects of Result 1 will now be examined. The inflow of unskilled labor reduces the wage rate of unskilled labor. This is the direct effect of unskilled labor importation and its magnitude depends on the factor intensity in that sector. However, it also produces a negative indirect effect on skilled labor. A rise in the productivity of capital in the first sector initiated by the importation of unskilled labor induces capital to flow from the second sector to the first sector. This reduces labor productivity in the second sector and produces a negative effect on the wage rate of skilled labor. This indirect effect and its magnitude depend on the factor intensity in the second sector. As the factor intensity in the second sector is greater than that of the first sector, the

wage rate of skilled labor declines more than that of unskilled labor, producing a wage inequality in favor of unskilled labor.

### 3 - 2. Skilled Labor Outflow

Consider a case where skilled labor outflow occurs due to  $w_2 < w_2^*$ . Assuming  $L_1$  and  $K$  are fixed, from Eqs. (1) - (3), we obtain:

$$\hat{w}_1 = - \left( \frac{\theta_{K1}}{\theta_{L1}} \frac{\lambda_{K2}}{\Phi} \right) \hat{L}_2 > 0 \quad (11)$$

$$\hat{w}_2 = - \left( \frac{\theta_{K2}}{\theta_{L2}} \frac{\lambda_{K2}}{\Phi} \right) \hat{L}_2 > 0 \quad (12)$$

$$\hat{w}_2 - \hat{w}_1 = \left( \frac{\theta_{K1}}{\theta_{L1}} - \frac{\theta_{K2}}{\theta_{L2}} \right) \frac{\lambda_{K2}}{\Phi} \hat{L}_2 > 0. \quad (13)$$

Eqs. (11) and (12) show that the wage rate of both types of labor increase as the result of a move out of skilled labor. The coefficient of  $\hat{L}_2$  in Eq. (13) is the elasticity of wage inequality with respect to the outflow of skilled labor. This generates the following result on wage inequality:

**Result 2.** *If the second sector is capital intensive, the emigration of skilled labor changes wage inequality in favor of skilled labor.*

Intuitively, the departure of skilled labor increases the scarcity of skilled labor, which increases the wage rate of skilled labor. This is the positive direct effect on skilled labor. However, it also induces capital to move from the second sector into the first sector, which increases the wage rate of unskilled labor. This is the positive indirect effect on unskilled labor. As the second sector is capital intensive, the direct effect dominates the indirect effect producing the wage inequality in

favor of skilled labor.

The outflow of skilled labor will occur when developed countries make technological transfers to, or direct investment in developing countries. If the technology transfer or direct investment is made in the form of skilled labor migration this will produce wage inequality in favor of skilled labor in the developed country. In such a case, the move out of skilled labor is beneficial to the skilled labor of developed countries.

### 3 - 3. Capital Outflow

Now consider the case where an outflow of capital occurs due to  $r < r^*$ . Assuming that  $L_1$  and  $L_2$  are fixed, from Eqs. (1) - (3), we obtain:

$$\hat{w}_1 = \left( \frac{\theta_{K1}}{\theta_{L1}} \frac{1}{\Phi} \right) \hat{K} < 0 \quad (14)$$

$$\hat{w}_2 = \left( \frac{\theta_{K2}}{\theta_{L2}} \frac{1}{\Phi} \right) \hat{K} < 0 \quad (15)$$

$$\hat{w}_2 - \hat{w}_1 = \left( \frac{\theta_{K2}}{\theta_{L2}} - \frac{\theta_{K1}}{\theta_{L1}} \right) \frac{1}{\Phi} \hat{K} < 0. \quad (16)$$

Eqs. (14) and (15) show that the outflow of capital reduces the wage rate for both types of labor.

The coefficient of Eq. (16) is the elasticity of wage inequality with respect to the outflow of capital.

As a consequence, we obtain:

**Result 3.** *If the second sector is capital intensive, then capital outflow changes wage inequality in favor of unskilled labor.*

The implications of the result 3 are as follows. Since capital is mobile between the two sectors, the outflow of capital reduces the marginal product of both types of labor, so that both types of labor suffer. This would explain the reason why the labor unions in the US opposed the outflow of capital in the 1980s. If capital moves out when the second sector is capital intensive, the marginal product of labor in the second sector declines more than that of the first sector making the wage gap favor unskilled labor. This is the intuition of Eq.(16). From results 2 and 3, we offer:

**Lemma 1.** *Suppose that the move out of skilled labor or capital is an alternative path for making technology transfer or direct investment. Then the move out of skilled labor is preferable for the domestic skilled labor.*

From Eqs. (10), (13), and (16), we obtain the following:

**Result 4.** *If the factor intensity is identical between the two sectors, international factor mobility has no impact on wage inequality. Thus, the difference in factor intensity is a necessary and sufficient condition for producing wage inequality.*

Result 4 suggests that with factor mobility the factor intensity between the two sectors plays a key role in producing wage inequality.

### **3 - 4. Inflow of All Three Factors**

Until now we considered the conventional cases in which a single factor migrates at a time.

However, as in the case of foreign direct investment, factors of production move simultaneously.

In this section, we consider a case where all three factors move into the country due to the varying levels of technology. Employing the results of the previous sub-sections, we consider a condition under which a simultaneous inflow of all three factors produces wage inequality in favor of skilled labor. It will be shown that the degree of factor mobility play is an important determinant in producing wage inequality in favor of skilled labor

An interesting point made by Davis and Weinstein (2002) is that all factors of production in the world are moving into the US due to its advanced state of technology. However they did not consider how this type of factor mobility is related to the wage inequality in the US.<sup>6</sup> In this section, we provide a condition under which the Davis-Weinstein type factor mobility produces wage inequality in favor of skilled labor and show that wage inequality in favor of skilled labor is inevitable under certain reasonable conditions. From Eqs.(10), (13), and (16), we obtain:

$$(\hat{w}_2 - \hat{w}_1) = \frac{1}{3} \left( \frac{1}{\Phi} \left( \frac{\theta_{K2}}{\theta_{L2}} - \frac{\theta_{K1}}{\theta_{L1}} \right) \right) (\hat{K} - \lambda_{K1} \hat{L}_1 - \lambda_{K2} \hat{L}_2). \quad (17)$$

We now introduce the following assumption:

**Assumption 1.** Due to the differences in technology, all three factors move into this country given the following degree of factor mobility:  $\hat{K} > (\lambda_{K1} \hat{L}_1 + \lambda_{K2} \hat{L}_2)$ .

With assumption 1, we now obtain:

**Result 5.** *The importation of all three factors produce wage inequality in favor of skilled labor.*

Result 5 shows that given the assumption above the skilled labor in the US gains from the inflow of all three factors. This assumption requires that the degree of capital inflow is greater than that of the weighted sum of the labor inflow, where the weight is the fraction of capital used in the particular sector. What remains to consider is the plausibility of this assumption and the factor intensity ranking.

This assumption has two aspects. First, as the result of superior technology all three factors move into the advanced country. Second, the degree of capital inflow is greater than that of the weighted sum of labor. On the first aspect, it is clear that as the US is the most innovative country in the world and the level of technology in the US is the highest in the world, hence all factors of production are now moving into the US. Examining the second aspect, it is reasonable so say that the degree of capital mobility is higher than that of the weighted sum of labor.<sup>7</sup> Looking at the factor intensity ranking, we see that as the skilled labor sector is more capital intensive than the unskilled labor sector, the second sector will be capital intensive. Thus, we can conclude that the wage inequality in favor of skilled labor is an inevitable outcome in the US.

Result 5 provides a reason why the wage inequality in favor of skilled labor has occurred in the past decade in the US. At first, it may be difficult to understand why the skilled labor in the US gains from the simultaneous inflow of all three factors. However, if the mobility of capital is very high and the second sector is capital intensive, the marginal product of skilled labor increases more than that of unskilled labor. This type of factor mobility will be promoted when a FTA is made between the US and other developing country.

#### 4. The Wage Gap with Capital Mobility

In the analysis of international labor mobility, conventional wisdom posits that labor movement between two countries reduces the initial wage gap and thus hampers the incentives for further labor migration.<sup>8</sup> However, this traditional view is derived with the assumption that capital is non-mobile. As an application of our model, this section considers the effects of labor movement on the wage gap with capital mobility. It is shown that this wisdom no longer holds when capital indeed mobile.

##### 4 - 1 An Inflow of Unskilled Labor

Consider the case of unskilled labor movement with capital having the capability to move. Suppose that this developed nation initially accepts unskilled labor from a developing country due to  $w_1 > w_1^*$  with  $w_2 = w_2^*$  and  $r = r^*$ . This unskilled labor importation will decrease  $w_1$  and increase  $w_1^*$ , which reduces the initial wage gap in unskilled labor and hampers the incentive for further migration. This is the direct effect of unskilled labor movement. However, as unskilled labor moves out of the developing country this will reduce  $r^*$  and increase  $r$ , which induces capital to move from the developing country to the developed country. This movement of capital will increase  $w_1$  and reduce  $w_1^*$ . Thus, there is an indirect effect of capital movement on the wage gap. Therefore, the importation of unskilled labor accompanies the importation of capital. This capital movement will continue until  $r = r^*$  is attained. Concerning the final situation, we are not sure whether the initial wage gap  $w_1 > w_1^*$  is reduced and will reduce the incentive for further unskilled labor migration. The net result depends on the magnitude of two effects.

#### 4 - 2. An Outflow of Skilled Labor

Next consider the case of skilled labor movement with capital mobility. Suppose that skilled labor departs this developed nation to a developing country due to the initial conditions of  $w_2 < w_2^*$  with  $w_1 = w_1^*$  and  $r = r^*$ . The loss of skilled labor from the developed country will increase  $w_2$  and reduce  $w_2^*$ , thereby reducing the initial wage gap of skilled labor. This is the direct effect of skilled labor movement. However the exodus of skilled labor reduces  $r$  and increases  $r^*$ , which induces capital to move out from the developed country to the developing country. This capital movement will reduce  $w_2$  and increase  $w_2^*$  and is the indirect effect of capital movement on the wage gap. Consequently the exit of skilled labor accompanies the migration of capital. This capital movement will continue until  $r = r^*$  is attained. We are not sure whether the initial wage gap in skilled labor between the two countries is reduced or not. The net result depends on the magnitude of two effects. Should the indirect effect of capital mobility dominate the direct effect of labor mobility, the initial wage gaps in skilled labor between the two countries may increase. Thus we have:

**Result 6.** *The prevailing conventional wisdom of the wage gap no longer holds when capital is mobile.*

There are two salient implications of result 6. The importation of unskilled labor accompanies the importation of capital while the exportation of skilled labor accompanies the exportation of capital. In other words, labor movement is accompanied by capital movement and the two factors move in the same direction. We now see how the capital mobility violates the validity of the conventional wisdom concerning the movement of labor on the wage gap. Result 6 provides the reason why

international labor mobility does not reduce the incentive to move labor mobility in the presence of capital mobility. As capital mobility is high in the real world, labor movement does not reduce the initial wage gap.

## **5. Conclusions**

The impact of factor mobility on wage inequality has been neglected in the previous literature. By the use of a specific factor model with factor mobility, this paper provided the following novel results on wage inequality and the wage gap in a developed economy.

First, by deriving the elasticity of wage inequality with respect to factor mobility, we showed that the difference in factor intensity plays a key role in producing wage inequality. Second, we provided a condition under which the Davis-Weinstein type of factor mobility produces wage inequality in favor of skilled labor and showed that wage inequality in favor of skilled labor can occur in the US. Third, we demonstrated that conventional wisdom concerning the wage gap no longer holds with capital mobility.

The following would seem to be rewarding topics for further research. First, the analysis of the effects of factor mobility on welfare would be necessary in order to obtain policy implications in the presence of wage inequality. Specifically if tax or subsidy policies on factor mobility are used in order to promote or reduce wage inequality, it will change welfare, income and thus factor prices. Second, the effects of international trade on wage inequality must be added. However, this aspect has already been taken up in the previous papers such as by Deardorff (2000) and Feenstra and Hanson(2003). In spite of these facts, we added new results in the analyses of wage inequality.

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## Footnotes

1. Two journals of international economics, *Journal of International Economics* 54, 2001 and *Review of International Economics* 8, 2000 have published a special issue on wage inequality. However no paper has taken up the effects of factor mobility on wage inequality.
2. Feenstra and Hanson (1996) demonstrated that investment and trade are important parts of the explanation for the pattern of wage and employment changes while Markusen and Venables(1997) focused on the role of multinational firm in explaining the wage inequality.
3. The domestic supply of factors of production can change through birth, education, and capital accumulation within a country. However in order to focus on the effects of factor mobility, we do not assume these situations.
4. The assumption of fixed commodity prices may limit the results of our analysis. However this has the following merits. First, the changes in nominal wages imply that of real wages. Second, the effects of international factor movements on factor prices become strong and clear.
5. Davis (1998) divided the effects of unskilled labor importation on labor market into two types: flexible-wage US type and rigid-wage Europe type. He insisted that in the former the wage inequality increases while in the latter the unemployment rate increases.
6. Their interest is on the welfare effects of immigration of factors. By the use of the Ricardian framework, they show that a country that experiences immigration of factors motivated by technological differences always loses from this migration.
7. For the evidence about the surge of capital mobility, see, for example, Wong (1995) Chap.1.
8. We give different meanings to wage inequality and wage gap. Wage inequality is the wage differential between skilled and unskilled labor within a country while the wage gap is the wage differential of same labor between the two countries.