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Innovation, Popularization of Higher Education and Employment

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Abstract

The paper investigates the relationship between the technological progress and labour market outcomes. Technological progress (innovation) may alter the required quality and quantity of labour for production. The impact on employment depends on the characteristic of the new production technology. On the one hand, if the technological progress is complementary to workers (the labour-intensive technological progress), employment tends to be increased by the technological change. On the other hand, the new technology serves to substitute for workers (the labour-saving technological progress), it tends to decrease employment. However, technological progress doesn't always have the same impacts on all types of workers. The paper examines how technological changes affect the wage, employment and unemployment in the dual labour market framework.

Keywords: Innovation, Technological progress, Employment, Unemployment, Skill.
JEL Classification: J24, J31, J64, O33, O38.

1. Introduction

According to OECD (2005), there are four types of innovation: (1) Product innovation; (2) Process innovation; (3) Marketing innovation; (4) Organisational innovation. Production innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. Process innovation is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. Marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. Organisational innovation is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations. Innovation (technological change) may alter the required quality and quantity of labour for production. The impacts of the new technologies on employment depend on the characteristic of the new production technology. On the one hand, if the technological progress is complementary to workers (the labour-intensive technological progress), employment tends to be increased by the technological change. On the other hand, the new technology serves to substitute for workers (the labour-saving technological progress), it tends to decrease employment. Thus all four types of innovation don't always expand employment. In general, product innovation tends to increase employment（Brouwer et al., 1993; Van Reenen 1997; Blanchflower and Burgess (1998); Smolny, 1998, 2002; Greenan & Guellec, 2000; Yang & Lin, 2008; Lachenmaier & Rottmann, 2011; Koski & Pajarinen, 2012). Namely, new technologies by product innovation are complementary to workers. However, process innovation, marketing innovation, and organisational innovation tend to decrease employment (Edquist et al., 2001). This implies that process innovation, marketing innovation, and organisational innovation tends to induce the labour-substitutive technological progress. In the light of expansion of job opportunities, production innovation is preferable to process innovation, marketing innovation, and organisational innovation. In the short run, technological changes have direct impacts on labour demand. However, technological changes also affect labour supply in the long run. Since employment is not determined only by the labour-demand side factors, those three innovations, i.e., process innovation, marketing innovation, and organisational innovation, don't always decrease the number of jobs in the long-run.

The characteristics of labour, especially, the education level of workers, have been changing. The proportion of college-educated people to all population has been increasing over last two decade in OECD countries (OECD, 2009a, 2013a). The ratio of tertiary education graduates to the all population increased nearly 20 percentage points on average in OECD countries between 1995 and 2011. On average across OECD countries, more than one-third of adults have attained a tertiary level of education (above upper secondary education) (OECD, 2013a). An increase in the number of highly-educated persons implies a rise in labour supply of skilled workers. Thus the number of unskilled workers becomes relatively smaller. On the one hand, this structural change in labour market tends to decrease the wage for skilled workers and thus tends to increase employment for skilled workers. On the other hand, the wage for unskilled workers tends to rise and thus unskilled employment tends to fall. In terms of wage differentials between skilled workers and unskilled workers, the popularization of higher education works in the direction to reduce the wage premium for skilled workers. In fact, the wage gap between skilled workers and unskilled workers has been historically decreasing.

This paper uses a two-sector general equilibrium model. I rely on the idea that wages and employment are determined by the intersection of an employment and a wage-setting schedule (Layard et al., 1991; Calmfors, 1994; Fukushima, 1998). Taking into account the popularization of higher education, i.e., a change in characteristics of labour supply, I study how the technological change (technological progress) affects the wage, employment, and unemployment in the labour market. More precisely, I analyse how the macroeconomic effects on the wage and employment of the skilled and the unskilled are different between when the technological change is a complementary to workers and when the technological progress is a substitute for workers. The next section of the paper sets the basic model. In Section III, first, I shall investigate the effects of the popularization of higher education on the labour market. Second, I shall analyse how the technological change affects the labour market. Section IV concludes.

2. The Model

There are two types of labour: skilled labour in a high-productivity sector (henceforth denoted the HP-sector) and unskilled labour in a low-productivity sector (henceforth denoted the LP-sector). A worker is either employed or unemployed. There are constant labour flows into the two sector. However, there is no labour flow between the HP-sector and the LP-sector. Namely, the two sectors are entirely separated from each other.

Wages and employment are determined by the intersection of an employment schedule and a wage-setting schedule (Layard et al., 1991; Calmfors、1994; Fukushima、1998). An employment schedule is derived from the ordinary profit-maximising behaviour of firms. The Shapiro-Stiglitz efficiency-wage model is used to model wage setting. Firms in both sectors employ workers who decide whether or not to shirk. Some of the shirking workers are discovered and fired. In addition, workers leave for other reasons. Firms make up for layoffs and quits by hiring new workers from the unemployment pool. Thus, the cost to a worker of being fired is to lose the job and go through at least one period of unemployment until he/she is hired by another firm. Because firms set their wages to avoid shirking, wages are above the market-clearing level. Therefore involuntary unemployment exists.

2.1. Labour Market Flows and Stocks

The various stocks and flows of labour are summarised in Figure 1. I assume that the economy finds itself in a steady state and thus that all stocks are constant. Moreover, I postulate a stationary total labour force, which is normalised to unity. All stocks of labour are measured as shares of the labour force in the economy. Individuals leave the labour market at a constant rate a, which is exactly the same rate as the rate of entry into the labour market. The new entrants, a, are new graduates from either upper-secondary education or tertiary education. I denote the fraction of new workers from tertiary education by h which is exogenously given. Thus the fraction of new workers from upper-secondary education is expressed by $1 - h$. The new workers from tertiary education into the HP-sector are ha and the new workers from upper-secondary education into the LP-sector are $(1 - h)a$. The share of employed workers in sector *i* is n_i and the share of unemployed workers is u_i (*i*=*H, L*). One the one hand, each period employed workers in sector *i* quit their present jobs at a given rate q (because wages are set so that no workers shirk and hence, no workers are fired). They cannot find a new job until they have been job seekers for at least one period. On the other hand, unemployed workers in sector *i* find their jobs at an endogenous determined rate s_i. In a steady state, all stocks have to be constant. Therefore, the condition for a steady state for employment in sector *i* is

$$(a + q)n_i = s_i u_i. \qquad (1)$$

The LHS is the outflow from employment and the RHS is inflows into the employment in sector *i*.

The conditions for constant unemployment in the HP-sector is

$$(a + s_H)n_H = qn_H + ha. \qquad (2)$$

The LHS is the outflow from unemployment and the RHS is inflows into the unemployment in sector *H*.

The conditions for constant unemployment in the LP-sector is

$$(a + s_L)n_L = qn_L + (1 - h)a. \qquad (3)$$

The LHS is the outflow from unemployment and the RHS is inflows into the unemployment in sector *L*.

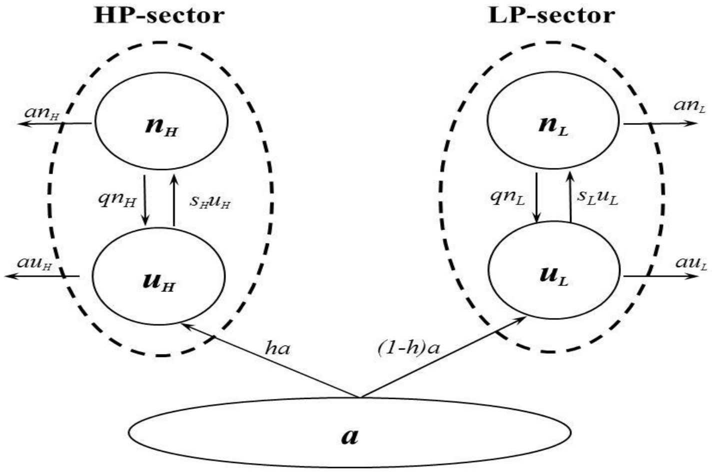
The steady –state conditions for both sectors can be expressed as

$$n_H + u_H = h, \qquad (4)$$

$$n_L + u_L = 1 - h. \qquad (5)$$

As we can see from these equations, the fraction of new workers from tertiary education (h) represents the total skilled labour force and the fraction of new workers from upper-secondary education ($1 - h$) is equal to total unskilled labour force. Equation (4) and equation (5) show that skilled workers increases and unskilled workers decreases in the economy when studying in higher education become more common, i.e., a rise in *h*.

Figure-1. Labour Market Flows and Stocks



2.2. Determination of Wages and Employment

The labour-demand curve is derived from the ordinary profit-maximising behaviour of firms. F identical firms produce a homogenous good through a decreasing-return-to-scale technology: $y_i^* = A_i(n_i^* + \theta_i^*)^\alpha$, where $0 < \alpha < 1$. y_i^* and n_i^* are the output and employment in each firm in sector *i*, respectively. A_i represents productivity in sector *i*, where $A_H > A_L$. θ_i^* is the production input other than labour. The relative price of the products is assumed to be given by the international market, and is normalised to unity. Each firm in sector *i* maximises its profit, $\pi_i^* = y_i^* - w_i^* n_i^*$, where w_i^* is the real wage in each firm. The first-order condition gives $w_i^* = \alpha A_i(n_i^* + \theta_i^*)^{\alpha - 1}$. Since $n_i^* = n_i/F, \theta_i^* = \theta_i/F$ and $w_i^* = w_i$ in a symmetrical equilibrium, the aggregate labour-demand schedule in sector *i* can be written:

$$w_i = BA_i(n_i + \theta_i)^{\alpha-1}. \qquad (6)$$

where $B = \alpha F^{1-\alpha} > 0$. Since $dw_i/dn_i < 0$ and $d^2\partial w_i/dn_i^2 > 0$, the labour-demand curve is downward-sloping and convex (see the LD-schedules in Figure 2). The labour-demand elasticity is constant and equal to $1/(1-\alpha)$.

Moreover, it is derived from equation (6) that $\partial w_i/\partial A_i = B(n_i + \theta_i)^{\alpha-1} > 0$ and $\partial w_i/\partial \theta_i = (\alpha - 1)B(n_i + \theta_i)^{\alpha-2} < 0$. As we can see from the first relationship, a rise in productivity (A_i) tends to increase the wage for the same level of employment. Namely, an increase in A_i shifts the labour demand-schedule upwards. The second derivatives shows that a rise in the amount of input other than labour (θ_i) tends to reduce the wage. This implies that a rise in θ_i shifts the labour demand-schedule downwards. In other words, a rise in A_i can be interpreted as a labour-intensive technological change and a rise in θ_i represents a labour-saving technological change.

I now turn to the wage-setting schedule. An individual's instantaneous utility function is $V(c,e)$, where c is the income and e is the effort. e can take only two values, zero and $\bar{e}$. e is zero if no effort is supplied on the job, i.e., for both shirking and unemployed workers. $\bar{e}$ is the non-negative effort level of non-shirking workers. The utility function is assumed to be additively separable and workers to be risk neutral. The utility function can then be written as $V(c,e) = c - e$.

Let $\Omega^{nj}_{i(t)}$ and $\Omega^{sj}_{i(t)}$ denote the discounted values of being employed for non-shirkers and shirkers, respectively, at time *t* in the *j*th firm of sector *i*. $\Omega_{ui(t)}$ is the discounted value of being unemployed in sector *i* at time *t*. It holds that

$$\Omega^{nj}_{i(t)} = \frac{1}{1+r}\left[w^j_{i(t)} - \bar{e} + q\Omega_{ui(t+1)} + (1-a-q)\Omega^{nj}_{i(t+1)}\right], \qquad (7)$$

$$\Omega^{sj}_{i(t)} = \frac{1}{1+r}\left[w^j_{i(t)} + (q+\bar{q})\Omega_{ui(t+1)} + (1-a-q-\bar{q})\Omega^{sj}_{i(t+1)}\right], \qquad (8)$$

$$\Omega_{ui(t)} = \frac{1}{1+r}\left[b + s_i\Omega_{i(t+1)} + (1-a-s_i)\Omega_{ui(t+1)}\right], \qquad (9)$$

where *r* is the rate of time preference assumed to be identical for all individuals. $w^j_{i(t)}$ is the wage at *t* in *j*th firm of sector *i* and *b* is the unemployment benefit. q is the exogenously given quit rate for workers and $\bar{q}$ is the exogenously given rate of being caught shirking. s_i is the probability for an unemployed worker in sector *i* to find a job.

Like Shapiro & Stiglitz (1984) I assume that firms determine wages for all future periods and that the economy finds itself in a steady state. Hence I can drop time subscripts and set $\Omega^{nj}_{i(t)} = \Omega^{nj}_{i(t)} = \Omega^{nj}_{i(t+1)} = \Omega^{nj}_i$, $\Omega^{sj}_{i(t)} = \Omega^{sj}_{i(t+1)} = \Omega^{sj}_i$ and $\Omega_{ui(t)} = \Omega_{ui(t+1)} = \Omega_{ui}$. I also assume a symmetric equilibrium, so that $w^j_{i(t)} = w_i$ for all *j*. Assuming that wages are set to avoid shirking, i.e., that $\Omega^{nj}_i = \Omega^{sj}_i = \Omega_i$, it can be derived from (7) - (9) that $w_i = b + (a + q + \bar{q} + r + s_i)(\bar{e}/\bar{q})$.

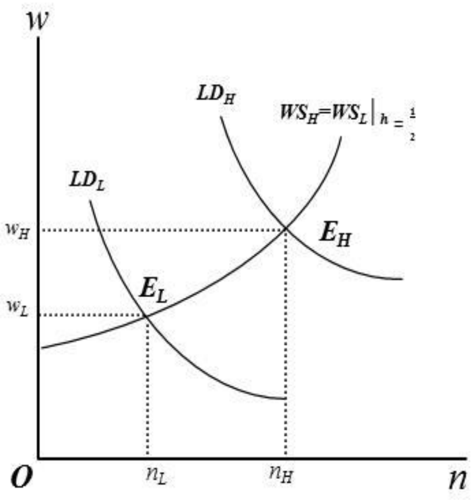
Taking equation (1), (4) and (5) into account, the wage-setting schedules become

$$w_H = C + D\frac{n_H}{h - n_H} \qquad (10)$$

$$w_L = C + D\frac{n_L}{1 - h - n_L} \qquad (11)$$

where $C = b + (a + q + \bar{q} + r)\bar{e}/\bar{q} > 0$ and $D = (a + q)\bar{e}/\bar{q} > 0$. It follows from equation (10) and equation (11) that $dw_H/dn_H = h/(h - n_H)^2 > 0$, $d^2w_H/dn_H{}^2 = 2\,h/(h - n_H)^3 > 0$ $dw_L/dn_L = (1-h)/(1-h-n_L)^2 > 0$, and $d^2w_L/dn_L{}^2 = 2\,(1-h)/(1-h-n_L)^3 > 0$. Thus the wage-setting schedules in both sectors are increasing and convex function of the sectoral employment. (see the WS-schedules in Figure 2).

Figure-2. Labour market equilibrium



2.3. Equilibrium

There are 12 exogenous variables: the fraction of new workers from tertiary education, h; the production input other than labour, θ_i; the productivity parameters, A_i; the unemployment unemployment benefit, b; the other `technical' parameters, $a, q, \bar{q}\, r, \alpha$; and the `scale' variable, *F*.

There are 8 endogenous variables in the model: $n_H, n_L, u_H, u_L, w_H, w_L, s_H$ and s_L, which are all simultaneously determined. The core variables, n_H, n_L, w_H and w_L are determined by equation (6), equation (10) and equation (11). The other endogenous variables, u_H, u_L, s_H and s_L, are given by equation (1), equation (4) and equation (5).

Figure 2 illustrates the general-equilibrium solution of the model. Wages are measured along the vertical axis and employment along the horizontal axis. The negatively sloped labour-demand curves are given by equation (6). The wage-setting schedules are given by equation (10) and equation (11). In this diagram, the wage-setting schedules are illustrated when the number of skilled workers in the HP sector is equal to the number of unskilled workers in the LP-sector, i.e., when $h = 1/2$. The equilibrium in the HP-sector is E_H and the equilibrium in the LP-sector is E_L.

3. Comparative Statics

First, I shall examine the effects of the popularization of higher education on the labour market. Second, I shall analyse how the macroeconomic effects on the wage and employment of the skilled and the unskilled are different between when the technological change is a complementary to workers and when the technological progress is a substitute for workers. In the following analysis, I shall start the initial equilibrium where the size of the labour markets in both the HP-sector and the LP-sector are the same, i.e., when $h = 1/2$. Moreover, the production inputs other than labour in the two sectors are assumed to be the same in the initial equilibrium, i.e., $\theta_1 = \theta_2$.

Since the popularization of higher education is represented by a rise in h, the effect of the popularization of higher education is derived from equation (6), equation (10) and equation (11) as

$$\frac{dn_H}{dh} = \frac{D\frac{n_H}{(h-n_H)^2}}{(1-\alpha)A_H B(n_H+\theta_H)^{\alpha-2} + D\frac{h}{(h-n_H)^2}} > 0, \qquad (12)$$

$$\frac{dn_L}{dh} = -\frac{D\frac{n_L}{(1-h-n_L)^2}}{(1-\alpha)A_L B(n_L+\theta_L)^{\alpha-2} + D\frac{1-h}{(1-h-n_L)^2}} < 0. \qquad (13)$$

Equation (12) and equation (13) show that a rise in *h* increases employment in the HP-sector and decreases employment in the LP-sector. When the number of workers who complete tertiary education increases, this implies an increase in the labour flow of new graduate into the skilled labour market. As a result, the wage in the HP-sector tends to decrease and thus employment tends to increase there.

However, in the LP-sector, the wage tends to increase and thus employment tends to fall. This is because the number of unskilled workers in the LP-sector becomes smaller. As can be seen from equation (6), equation (10) and equation (11), a change in *h* affects only the wage-setting schedules and has no impact on the labour-demand schedules. Namely, a rise in *h* shifts the wage-setting schedule in the HP-sector downwards and that in the LP-sector upwards. Figure 3 illustrates this situation. An increase in the number of new graduates from tertiary education tends to shift the wage-setting schedule in the HP-sector from WS_L to WS_L' and shifs the wage-setting schedule in the LP-sector from WS_L to WS_L'. The equilibrium for the HP-sector moves from E_H to E_H' and for the LP-sector moves from E_L to E_L'. As can be seen from Figure 3, the wage decreases and employment increases in the HP-sector. In the LP-sector, the wage increases and employment decreases. Turning to the wage differential between the skill and the unskilled, the popularization of higher education tends to decrease the wage premium for skilled workers.

The effect on aggregate employment is derived from equation (12) and equation (13) as

$$\frac{dn_H}{dh}+\frac{dn_L}{dh}=\frac{D\frac{n_H(1-h)-n_L h}{(h-n_H)^2(1-h-n_L)^2}+(1-\alpha)\left[\frac{n_H}{(h-n_H)^2}A_L B(n_L+\theta_L)^{\alpha-2}-\frac{1-h}{(1-h-n_L)^2}A_H B(n_H+\theta_H)^{\alpha-2}\right]}{\left[(1-\alpha)A_H B(n_H+\theta_H)^{\alpha-2}+D\frac{h}{(h-n_H)^2}\right]\left[(1-\alpha)A_L B(n_L+\theta_L)^{\alpha-2}+D\frac{1-h}{(1-h-n_L)^2}\right]}>0.$$

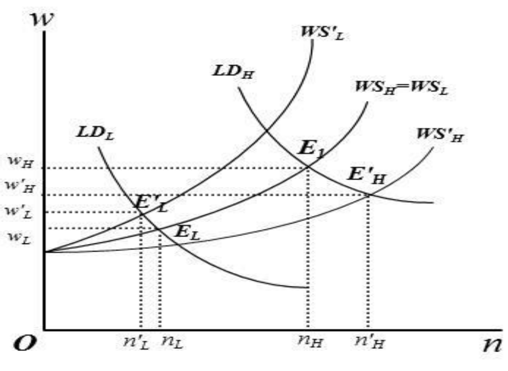
The equation above shows that the popularization of higher education increases aggregate employment in the economy. Together with equation (12) and equation (13), an increment of skilled employment is larger than a decrement of unskilled employment and thus aggregate employment is increased. This implies that aggregate unemployment is decreased by the popularization of higher education. More precisely, the effects on unemployment in the two sectors can be derived from equation (4), equation (5), equation (12), and equation (13) as

$$\frac{du_H}{dh}=1-\frac{dn_H}{dh}=\frac{(1-\alpha)A_H B(n_H+\theta_H)^{\alpha-2}+D\frac{h-n_H}{(h-n_H)^2}}{(1-\alpha)A_H B(n_H+\theta_H)^{\alpha-2}+D\frac{h}{(h-n_H)^2}}>0, \quad (14)$$

$$\frac{du_L}{dh}=-1-\frac{dn_L}{dh}=-\frac{(1-\alpha)A_L B(n_L+\theta_L)^{\alpha-2}+D\frac{1-h-n_L}{(1-h-n_L)^2}}{(1-\alpha)A_L B(n_L+\theta_L)^{\alpha-2}+D\frac{1-h}{(1-h-n_L)^2}}<0. \quad (15)$$

A rise in the number of highly-educated persons increases unemployment in the HP-sector and decreases unemployment in the LP-sector.

Figure-3. The effects of an increase in *h*



Next I shall investigate how the technological change affects the economy. As can be seen from equation (6), equation (10) and equation (11), only the labour-demand schedules are affected by technological changes. In other words, the technological change affects the economy in this model only through the wage-setting schedules. First, I shall analyse the case when the technological progress is a substitute for workers. Second, the effects of a labour-complementary technological progress are investigated.

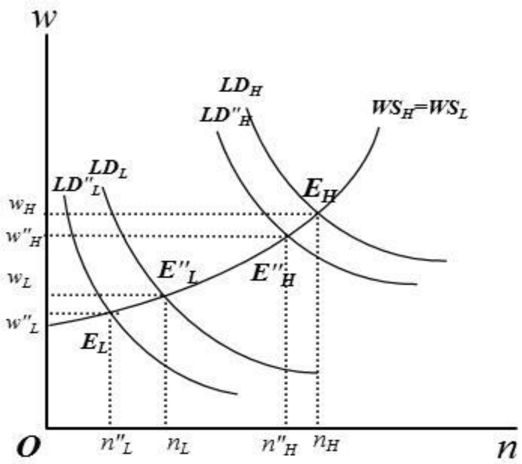
The labour-substitute (saving) technological progress in this model is expressed as a rise in θ_i. If the technological progress is a substitute for workers, this tends to decrease employment. More precisely, the effects of a change in θ_i on employment in the two sectors can be derived from equation (6), equation (10) and equation (11) as

$$\frac{dn_H}{d\theta_H} = -\frac{(1-\alpha)A_H B(n_H+\theta_H)^{\alpha-2}}{(1-\alpha)A_H B(n_H+\theta_H)^{\alpha-2}+D\frac{h}{(h-n_H)^2}} < 0, \qquad (16)$$

$$\frac{dn_L}{d\theta_L} = -\frac{(1-\alpha)A_L B(n_L+\theta_L)^{\alpha-2}}{(1-\alpha)A_L B(n_L+\theta_L)^{\alpha-2}+D\frac{1-h}{(1-h-n_L)^2}} < 0. \qquad (17)$$

The negative signs in equation (16) and equation (17) imply that employment in both sectors are reduced by labour-saving technological changes. Namely, a rise in θ_i tends to shift the labour-demand schedule downwards. Figure 4 illustrates this situation. The labour-substitute (saving) technological progress shifts the labour-demand schedule in the HP-sector from LD_H to LD_H' and shifs the labour-demand schedule in the LP-sector from LD_L to LD_L'. The equilibrium for the HP-sector moves from E_H to E_H" and for the LP-sector moves from E_L to E_L". As can be seen from Figure 4, both the wage and employment decrease in both sectors.

Figure-4. The effects of an increase in θ_i



Moreover, I shall investigate in which sectors the employment-reduction effect is greater. From equation (16) and equation (17), I have

$$\frac{dn_H}{d\theta_H} - \frac{dn_L}{d\theta_L} = \frac{(1-\alpha)B\left[A_L(n_L+\theta_L)^{\alpha-2}D\frac{h}{(h-n_H)^2} - A_H(n_H+\theta_H)^{\alpha-2}D\frac{1-h}{(1-h-n_L)^2}\right]}{X} > 0, \qquad (18)$$

where

$X =$
$[(1-\alpha)A_H B(n_H+\theta_H)^{\alpha-2} + Dh/(h-n_H)^2][(1-\alpha)A_L B(n_L+\theta_L)^{\alpha-2} +$
$D(1-h)/(1-h-n_L)^2]$.

The equation above shows that the employment-reduction effect is larger in the LP-sector than in the HP-sector. This implies that the labour-saving technological change have a greater impact on the unskilled labour market.

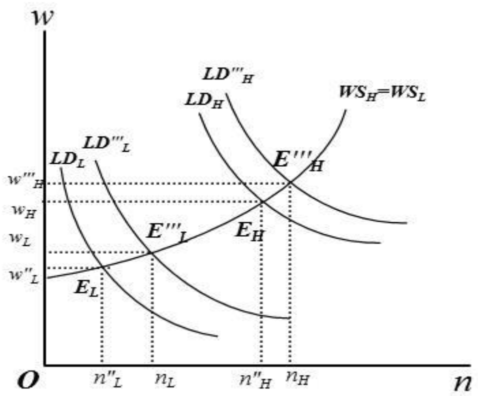
The labour-complementary (intensive) technological progress in this model is expressed as a rise in A_i. If the technological progress is a complementary to workers, this tends to increase employment. More precisely, the effects of a change in A_i on employment in the two sectors can be derived from equation (6), equation (10) and equation (11) as

$$\frac{dn_H}{dA_H} = -\frac{B(n_H+\theta_H)^{\alpha-1}}{(1-\alpha)A_H B(n_H+\theta_H)^{\alpha-2}+D\frac{h}{(h-n_H)^2}} > 0, \qquad (19)$$

$$\frac{dn_L}{dA_L} = -\frac{B\,(n_L+\theta_L)^{\alpha-1}}{(1-\alpha)A_L B(n_L+\theta_L)^{\alpha-2}+D\frac{1-h}{(1-h-n_L)^2}} > 0. \qquad (20)$$

The positive signs in equation (19) and equation (20) imply that labour-intensive technological changes in both sectors increase employment. Namely, a rise in A_i tends to shift the labour-demand schedule upwards. Figure 5 illustrates this situation. The labour-complementary (intensive) progress shifts the labour-demand schedule in the HP-sector from LD_H to LD_H''' and shifs the labour-demand schedule in the LP-sector from LD_L to LD_L'''. The equilibrium for the HP-sector moves from E_H to E_H''' and for the LP-sector moves from E_L to E_L'''. As can be seen from Figure 5, both the wage and employment increase in both sectors.

Figure-5. The effects of an increase in A_i



Moreover, I shall investigate in which sectors the employment-creation effect is greater. From equation (19) and equation (20), I have

$$\frac{dn_H}{dA_H} - \frac{dn_L}{dA_L} = B\,\frac{D\left[\frac{(1-h)(n_H+\theta_H)^{\alpha-1}}{(1-h-n_L)^2} - \frac{h(n_L+\theta_L)^{\alpha-1}}{(h-n_H)^2}\right] + (1-\alpha)B\left[\frac{A_L(n_L+\theta_L)^{\alpha-2}}{(n_H+\theta_H)^{\alpha-1}} - \frac{A_H(n_H+\theta_H)^{\alpha-2}}{(n_L+\theta_L)^{\alpha-1}}\right]}{X} > 0, \qquad (21)$$

The equation above shows that the employment-creation effect is greater in the HP-sector than in the LP-sector. This implies that the labour-complementary technological change have a greater impacts on the skilled labour market.

Lastly, I shall examine the following possibility. Even when the labour-substitute (saving) technological progress is brought about in one sector, aggregate employment might be increased if the labour-complementary technological progress occurs in another sector. More precisely, I shall investigate the case when the labour-complementary (intensive) technological progress occurs in the HP-sector and labour-complementary (intensive) technological progress is brought about in the LP-sector. When a rise in A_H and an increase in θ_L arise at the same time, it follows from equation (17) and equation (19) that the impact on aggregate employment can be expressed as

$$\frac{dn_H}{dA_H} + \frac{dn_L}{d\theta_L} = \left[\frac{n_H+\theta_H-(1-\alpha)A_H}{(1-\alpha)A_H}\right] - \frac{D(1-\alpha)\left[\frac{hA_L(n_L+\theta_L)^{\alpha-2}}{(h-n_H)^2} - \frac{(1-h)A_H(n_H+\theta_H)^{\alpha-2}}{(1-h-n_L)^2}\right]}{X} \gtreqless 0, \qquad (22)$$

As can be seen from the above equation, the impact on aggregate employment is ambiguous.

4. Concluding Remarks

This paper has analysed the impacts of the popularization of higher education and technological changes on the labour market in a general equilibrium framework. When the number of workers who complete higher education increases, the wage of the skilled tends to fall and thus skilled employment tends to rise. In contrast, the wage for unskilled tends to increase and unskilled employment tends to decrease. This is because the supply of skilled workers becomes relatively greater than that of unskilled workers. However, since an increment of skilled employment is larger than a decrement of unskilled employment, aggregate employment is increased. In addition, the wage gap between skilled workers and unskilled workers is reduced by the popularization of higher educationThe labour-substitute (saving) technological progress decreases both the wage and employment. The employment-reduction effect on the unskilled is larger than that on the skilled. This implies that the labour-saving technological change have a greater impacts on the unskilled labour market.The labour-complementary (intensive) progress increases both the wage and employment. The employment-creation effect on the skilled is greater than that on the unskilled. This implies that the labour-complementary technological change have a greater impacts on the skilled labour market.

When the labour-complementary (intensive) technological progress occurs in the skilled-sector and labour-complementary (intensive) technological progress is brought about in the unskilled-sector at the same time, in general, it is ambiguous whether aggregate employment increases or not.

Refernces

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