

**TRADE, HUMAN CAPITAL  
AND  
LABOUR MARKET ADJUSTMENT\***

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**Abstract**

This paper highlights the way in which workers of different age and ability profiles are affected by an unexpected trade liberalisation. A two-factor, two-good general equilibrium model of international trade and human capital is constructed. Whether to remain unskilled is an individual's investment decision that can be reversed in the future through schooling. Individuals differ not only in their endogenous education level but also in their exogenous ability level and age. Adjustment costs are not only of the Stolper-Samuelson type. Trade liberalisation, by affecting wages, will also affect returns to education. We find that in unskilled labour abundant countries, trade liberalisation leads to progressive skill downgrade and a shift to specialisation in the unskilled labour intensive good; the converse holds for skill abundant countries. Adjustment is a dynamic process that may take significantly more time than suggested by traditional analysis. Older workers differ from younger workers in the proportion of population (in each generation) negatively affected by trade liberalisation and in the severity of losses. Results show that subsidies to compensate losers should be higher for young skilled workers in unskilled labour abundant countries, and older unskilled workers in skill abundant countries.

Keywords: International trade, Factor mobility, Labour market adjustment.

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# 1. OVERVIEW

In recent decades the reduction of trade barriers has been accompanied by an ongoing increase in concern about the political, social and economic impact of trade liberalisation. Moreover, particular attention has been paid to the private costs associated with the transition between the pre- and the post-liberalisation equilibrium. Against this background, developing an analytical framework that provides an understanding of adjustment as a dynamic process and explicitly models the losses induced by trade liberalisation appears to be of great importance.

Most international trade models that explicitly analyse the relationship between trade expansion and labour market adjustment costs, focus on the rise of wage inequality associated with labour reallocation between contracting and expanding industries (or firms). In this paper, we argue that the existing literature underestimates the impact of trade liberalisation for two main reasons. Firstly, another channel exists through which trade liberalisation, by affecting relative wages, causes capital losses. In particular, changes in relative wages lead to changes in the returns on education. Secondly, by treating workers within each skill group as homogeneous, most existing trade literature implicitly assumes that all workers (independent of their age, experience level and ability profile) are equally affected by trade liberalisation. That, however, is not consistent with the labour economics literature that argues that earning profiles depend not only on the education level but also on these other individual characteristics.

This paper highlights the way in which workers of different age and ability profiles are affected by an unexpected trade expansion. We consider a two-country world where both are closed economies that open to trade. There are two factors of production: skilled and unskilled labour, neither of which is sector specific.

Each economy consists of two manufacturing and one educational sector. The manufacturing sectors are: Low-Tech and High-Tech. Each uses skilled and unskilled

labour and has flexible technology<sup>1</sup>. The good produced by the high-tech sector is relatively skill intensive. In addition, we consider the usual assumptions of the Heckscher-Ohlin-Samuelson (H-O-S) model of international trade. However, human capital acquisition is endogenous. Following Becker (1964 and 1993), Becker-Chiswick (1966) and Mincer (1974 and 1993) we explicitly model educational investments accounting for the relationship between earning profiles; and ability and age. Being unskilled or becoming skilled is an individual's investment decision. Unskilled workers are those who enter the labour force without educational training. Education is an activity that transforms individuals with only ordinary and general skills into skilled workers after an exogenous lapse of time. In the model it is not costless. Moreover, we allow individuals to change their labour status at any time in their lives. In contrast to previous models [e.g. Borsook (1986), Findlay and Kierzkowski (1983)] the decision to enter the labour market as unskilled can be reversed in the future through schooling. The existence of constraints on workers' mobility between occupations (in the form of educational training costs) is the only rigidity we impose in the labour market. Furthermore, we assume that individuals differ not only in their endogenous education level but also in their exogenous ability level and age. The return to higher education is an increasing function of ability level and a decreasing function of age. Adjustment is modelled as a dynamic process.

In this context, trade is motivated by differences between countries in relative factor endowments. These differences are endogenous. They can be motivated either by differences in life expectancies and birth rates; by differences in the efficiency of the educational sector and differences in the duration of the schooling process.

Trade liberalisation by affecting relative wages, will also affect the returns on education. Students, unskilled and skilled workers will have different reactions. Both the incentive to acquire education and the returns on acquired education change as a consequence of trade liberalisation.

Within each skill group the gains or losses implied differ. They depend on workers' age. The rationale lies in the fact that, in the first entry to the labour market,

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<sup>1</sup> Each industry can adjust the skilled and unskilled labour usage per unit of output, in absolute and relative terms, in response to an exogenous change in input prices.

an individual has to decide between entering as an unskilled worker or engaging in educational training and entering later as a skilled worker. For individuals that are no longer at the beginning of their working life, trade liberalisation occurs after committing to a course of action based upon his/her expectations regarding future prices and labour market conditions. Given the new circumstances, an individual who (given his/her level of ability) has made his educational decision at the beginning of the working life, will observe returns on education different from expected.

The model brings additional insights on two domains: dynamics of labour supplies during the transition period and trade induced gains and losses.

First, we conclude that trade leads to progressive skill upgrading in skilled labour abundant countries; the converse holds for skill abundant countries. Adjustment is a dynamic process that may take significantly more time than considered by traditional analysis. Until the new steady-state is achieved, the skilled/unskilled labour abundant country will have a skill endowment below/above the steady-state equilibrium level. The rationale lies in the fact that, although all individuals are allowed to reverse their previous educational decision, for many, at the time of trade liberalisation, it is too late to do so. Worker moves between occupations are costly and not all unskilled workers with an ability level higher than the new steady state cut-off will become skilled, nor will all skilled workers with an ability level lower than the new steady state cut-off reverse their labour status. The dynamics of labour supply have effects on specialisation. In particular, in skill abundant countries, trade liberalisation leads to a progressive shift to specialisation in the skill intensive good and in unskilled labour abundant countries, to a progressive shift to specialisation in the unskilled intensive good.

Second, in skilled labour abundant countries, skilled workers and students are winners of trade liberalisation. They have capital gains in the form of higher returns on education. Among skilled workers with the same level of ability, gains are lower for older individuals. Conversely, among students, gains are lower for younger individuals that will have to pay higher tuition fees for longer.

On the other hand, unskilled workers are losers. The transition will involve changes of occupation, which implies educational training costs. These costs are made higher as a consequence of trade liberalisation. This is particularly harmful to

older workers since they have a shorter period of return to the investment in education. Among those that change occupation, the more able face a rate of return on education below its potential level - younger counterparts with identical level of ability are better off. The remaining, will escape wage losses but will be worse off than in the absence of trade liberalisation.

Older workers differ from younger workers in the proportion of population in each generation negatively affected by trade liberalisation and in the severity of the losses - both higher for older generations.

In unskilled labour abundant countries, unskilled workers are winners of trade liberalisation. However, the higher their age the lower the gains induced by trade liberalisation.

On the other hand, students and skilled workers are losers. All students and skilled workers will face a disappointing rate of return on education - returns on education lower than expected when they committed their course of actions. There will be capital losses, in the form of negative returns on education, for the less able students and skilled workers. These losses are especially high for those that in spite of having invested in education, under the new factor prices, would rather work as unskilled. The transition may involve costly occupational change for those whose post-trade lifetime earnings as skilled are lower than as unskilled.

Trade is more penalising for younger than older generations. In younger generations there will be more skilled workers facing negative returns on the investment in education and more students deciding to drop school. Across individuals with the same level of ability, younger individuals' suffer higher capital losses on their investment in education and higher negative differences between the expected and effective rate of return on education.

The results of the model show subsidies to compensate losers should be higher for older unskilled workers in skill abundant countries and young skilled workers in unskilled labour abundant countries.

## 2. THE MODEL

### 2.1. Technology

Consider an economy producing two goods, low-tech (1) and high-tech (2), using two productive factors, unskilled (L) and skilled labour (S)<sup>2</sup> measured in efficiency units. The quantity of skilled labour services available for use in manufacturing ( $S_M$ ) depends upon the quantity of skilled labour services allocated to education ( $S_E$ ) which, in turn, depends on the number of students. Factors are immobile between countries, but mobile between sectors within the country.

The production function of goods is assumed to be neoclassical and is given by

$$X_j = F_j(L_j, S_j) \quad (1)$$

in which  $X_j$  is the output of the commodity produced in industry  $j$  and  $L_j$  and  $S_j$  are, respectively, the amount of unskilled and skilled labour employed in industry  $j$ .

Consider constant returns to scale and convex production technology,

$$x_j = f_j(l_j), \quad \frac{\partial x_j}{\partial l_j} > 0, \quad \frac{\partial^2 x_j}{\partial l_j^2} < 0 \quad (2)$$

where  $x_j = X_j/S_j$  and  $l_j = L_j/S_j$ .

Furthermore, consider perfectly competitive markets for goods and factors.

In equilibrium, and assuming incomplete specialization,

$$P_j = a_{Lj}W_{Lj} + a_{Sj}W_{Sj} \quad (3)$$

where  $P_j$  is the price of output  $j$  ( $j=1, 2$ );  $a_{Lj}$  and  $a_{Sj}$  are, respectively, the equilibrium requirement of unskilled and skilled labour per-unit of output  $j$ ; and  $W_{Lj}$  and  $W_{Sj}$  are, respectively, the returns to unskilled and skilled labour per efficiency unit.

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<sup>2</sup> To keep the analysis direct and focused on the dynamics of labour adjustment process, we will abstract from the consideration of physical capital as a third factor.

Moreover, profit maximization leads to the condition that in each sector, each efficiency unit of each type of labour must be paid the marginal value product

$$W_{L_j} = P_j * \frac{\partial X_j}{\partial L_j} \quad (4a)$$

$$W_{S_j} = P_j * \frac{\partial X_j}{\partial S_j} \quad (4b)$$

Since, in the long run, factors are homogeneous and costlessly mobile between industries, the values of  $W_{L_j}$  and  $W_{S_j}$  are common across industries ( $W_{L_j} = W_L$  and  $W_{S_j} = W_S, \forall j$ ).

Hence, for given output prices, national income is maximized when factors are allocated so as to equate their marginal value product across industries and that depends on the intensity of usage of the production factor.

Assume that the full employment conditions have to be fulfilled

$$L = L_1 + L_2 = a_{L1} X_1 + a_{L2} X_2 \quad (5a)$$

$$S = S_M + S_E = (S_1 + S_2) + S_E = (a_{S1} X_1 + a_{S2} X_2) + a_{SE} * X_E \quad (5b)$$

where  $L$  and  $S$  denote, respectively, the stock of each of the production factors.  $a_{SE}$  is the equilibrium requirement skilled labour per student and  $X_E$  denotes the output of the education sector.

In contrast to unskilled labour, not all the existing stock of skilled labour is available for goods manufacturing. Education is an activity that transforms individuals with only ordinary and general skills into skilled workers after an exogenous lapse of time. Educational services are provided to students by skilled labour ( $S_E$ ) and only after each student spends  $E$  time with  $\beta \in ]0,1]$  efficiency units of skilled labour can he/she work as skilled.  $X_E$  (new skilled workers) equals the number of students and  $a_{SE}$  equals  $\beta$ . At any time, the amount of skilled labour, measured in efficiency units, allocated to education equals  $\beta$  times the number of students. This parameter is a measure of efficiency of the educational sector. The lower  $\beta$  is, the higher the productivity of one efficiency unit of skill employed in the educational sector.

Finally, assume that at any common factor prices,

$$\frac{S_2}{L_2} > \frac{S_1}{L_1} \quad (6)$$

that is, there are no factor intensity reversals, with the high-tech sector (2) always being the skill intensive sector.

## 2.2. Individual Investment behaviour and Human Capital Acquisition

### 2.2.1. Investment in Formal Education

Consider an economy in which individuals are assumed to be heterogeneous with respect to their ability. Ability is a combination of ordinary and general knowledge that is innate and is acquired during the background period prior to working age<sup>3</sup>. Individuals are indexed by their ability ( $\alpha$ ) which is uniformly distributed among the population and varies along the unit interval:  $\alpha \in [0,1]$ .

Before entering the labour market, each individual faces a choice between investing in formal education for an additional length of time or entering the labour force immediately. Under this framework, schooling choice will determine labour market status. Only by spending some extra time at school (that we consider to be a fixed length of time  $E$ ) can the individual be employed as a skilled worker. In this case, on top of his initial (uniformly distributed) ability, he/she will have some level of human capital.

Assume that each individual's working lifetime is finite and exogenously given by time  $T$ . Thus, the working lifetime of a skilled worker is  $T - E$  and of an unskilled worker is  $T$ .

Furthermore, suppose that gross working earnings, per period, of an unskilled worker do not depend on his ability and are equal to  $W_L$ . Gross working earnings of a skilled worker depend on the number of efficiency units of skill he/she possesses<sup>4</sup> and are equal to  $\alpha W_S$ . In doing so we depart from the assumption that skilled labour is

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<sup>3</sup> Note that we can interpret this background period, for example, as the compulsory stages of education.

<sup>4</sup> This assumption is based on the idea that unskilled workers jobs involve more trivial tasks, on which the worker either succeeds or fails, while skilled workers job involves more complex tasks on which the degree of performance can differ - the time taken depends on the workers ability.



homogeneous: skilled workers differ in the supplied level of ability and, therefore, in their net earnings.

Moreover, net earnings of skilled workers differ from gross earnings: formal education is both time and resource consuming. During the schooling period the individual will earn no income and will have some costs. Let's assume that becoming skilled involves a sunk cost. Each person who wants additional school training has to rent  $\beta$  efficiency units of skilled labour, with  $\beta \in ]0,1]$ . Therefore, in each of the  $E$  periods that education takes, its direct cost will be equal to the reward of one efficiency unit of skill times  $\beta$ .

In addition to the direct cost of schooling, there is an indirect cost: forgone working earnings as an unskilled worker.

Thus, becoming skilled involves an investment in formal education. The net present value of this investment is the difference between the discounted benefits – higher earnings of skilled workers relative to unskilled workers – and the discounted costs – tuition and forgone earnings. Mathematically, the present value of net returns to education  $[R(\alpha)]$  equals<sup>5</sup>

$$R(\alpha) = \int_E^T (\alpha W_S - W_L) e^{-rz} dz - \int_0^E (\beta W_S + W_L) e^{-rz} dz \quad (7)$$

where  $r$  is the interest rate in a perfect capital market.

The higher  $R(\alpha)$ , the better the investment. We assume that all individuals that expect positive net returns to schooling will undertake the investment. Therefore, solving for  $R(\alpha) = 0$  we get the level of ability starting from which individuals choose to engage in further education ( $\tilde{\alpha}$ ):

$$\tilde{\alpha} = \frac{e^{rT}(e^{rE} - 1)}{e^{rT} - e^{rE}} \beta + \frac{e^{rE}(e^{rT} - 1)}{e^{rT} - e^{rE}} \frac{W_L}{W_S} = \Gamma \beta + (1 + \Gamma)w = w + \Gamma(\beta + w) \quad (8)$$

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<sup>5</sup> Note that we are assuming that educational training is undertaken before starting to work. To the extent that the investment is profitable, its postponement would reduce the discounted net returns. Under our framework, in equilibrium it would not be sensible for any individual to work first as unskilled and only undertake schooling afterwards. The rationale lies in the fact that the individual would earn the unskilled wage during an extra time when he could be earning the skilled wage rate.

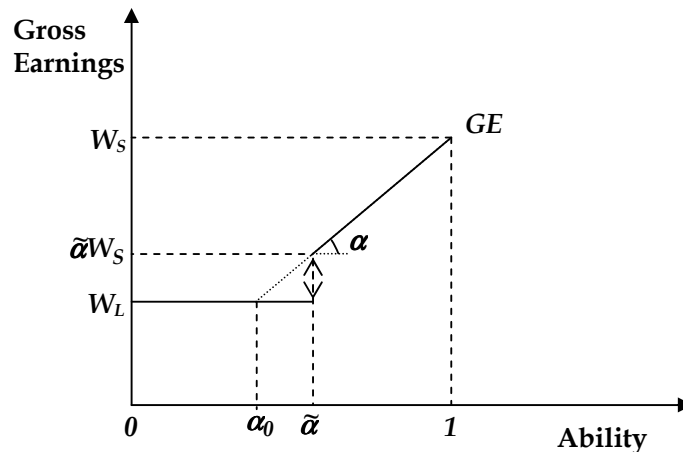
with  $\Gamma = \frac{e^{rT}(e^{rE}-1)}{e^{rT}-e^{rE}}$  and  $w = \frac{W_L}{W_S}$ .

Therefore, an individual with  $\alpha > \tilde{\alpha}$  decides to become skilled and an individual with  $\alpha \leq \tilde{\alpha}$  enters the labour market immediately as unskilled.

As  $\Gamma > 0$ ,  $\beta > 0$  and  $w > 0$ , the critical level of ability ( $\tilde{\alpha}$ ) is always higher than zero. Note that if becoming skilled was instantaneous ( $E = 0$ ),  $\tilde{\alpha}$  would simply equal the relative wage ( $\Gamma = 0$ ). The existence of a costly schooling period to become skilled ( $E > 0, \beta > 0$ ) implies a decrease in the number of skilled workers and an increase in the average level of ability of the skilled labour force.

Figure 1 illustrates the relation between ability level and gross earnings.  $GE$  is the gross earnings function. In equilibrium, individuals with ability in the interval  $[0, \tilde{\alpha}]$  choose not to acquire skills and spend their entire working life earning  $W_L$  (per period). The gross earnings of unskilled workers do not depend on ability level so  $GE$  is horizontal in this interval. Individuals with higher levels of ability will decide to become skilled and spend their post-educational training work life earning  $\alpha W_S$  (per period). Gross earnings of skilled workers depend positively on ability. They vary along the interval  $[\tilde{\alpha} W_S, W_S]$ . In this interval  $GE$  is a line with positive slope  $\alpha$ . In the absence of an educational training period,  $GE$  would be continuous. Individuals with ability in the interval  $[\alpha_0, \tilde{\alpha}]$  would decide to become skilled. Under the defined setting this is not the case. For  $\alpha = \tilde{\alpha}$ , with  $E > 0$  and  $\beta > 0$ ,  $W_L \neq \tilde{\alpha} W_S$ .

**Figure 1 - Ability and Gross Earnings**



The defined equilibrium can change as a consequence of a change in relative wages:

$$\frac{\partial \tilde{\alpha}}{\partial w} = 1 + \Gamma > 0 \quad (9a)$$

$$\varepsilon_{\tilde{\alpha},w} = \frac{1}{\frac{e^{r^T}(e^{r^E}-1)\beta}{e^{r^E}(e^{r^T}-1)w} + 1} = \frac{1}{\frac{\Gamma}{1+\Gamma} \frac{\beta}{w} + 1} < 1 \quad (9b)$$

where  $\varepsilon_{\tilde{\alpha},w}$  is the elasticity of the critical level of ability to the relative wage ( $W_L / W_S$ ).

Eq. 9a shows that an increase in the relative wage of unskilled workers increases the incentive to stay unskilled. Eq. 9b shows that this change is less than proportional to the change in the relative wage: the elasticity of the critical level of ability in relation to the relative wage of unskilled workers is lower than 1.

By specifying the rate of return to investment in education [ $r_E(\alpha)$ ], the relation between discounted benefits and costs can be derived in a different way from computing the net income gains from education [ $R(\alpha)$ ]. Defining  $r_E(\alpha)$  as discounted benefits relative to the discounted costs<sup>6</sup>, we get the following expression:

$$r_E(\alpha) = \frac{\int_E^T (\alpha W_S - W_L) e^{-rz} dz}{\int_0^E (\beta W_S + W_L) e^{-rz} dz} = \frac{e^{r^T} - e^{r^E}}{e^{r^T}(e^{r^E}-1)} \frac{\alpha - w}{\beta + w} = \frac{1}{\Gamma} \frac{\alpha - w}{\beta + w} = \frac{\alpha - w}{\tilde{\alpha} - w} \quad (10)$$

$r_E(\alpha)$  is higher than one for all skilled workers [note that only the individuals with  $\alpha > \tilde{\alpha}$  decide to become skilled, that  $r_E(\alpha)$  is increasing in  $\alpha$  and that for  $\alpha = \tilde{\alpha}$ ,  $r_E(\alpha) = 1$ ]. Among individuals belonging to this skill group there will be differences in this rate. Eq. 11 shows that the higher the level of ability of the worker, the higher the rate of return to the investment in education.

$$\frac{\partial r_E(\alpha)}{\partial \alpha} = \frac{1}{\Gamma(\beta + w)} = \frac{1}{\tilde{\alpha} - w} > 0 \quad (11)$$

$$\varepsilon_{r_E,\alpha} = \frac{\alpha}{\alpha - w} > 1 \quad (12)$$

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<sup>6</sup> We define the rate of return to the investment in education as the wage gains (working earnings as high skilled minus working earning as low-skilled for  $T - E$  periods) relative to education (direct and indirect) costs for  $E$  periods.

Changes in the relative wage will affect the returns to investment in education.

$$\frac{\partial r_E(\alpha)}{\partial w} = -\frac{1}{\Gamma} \frac{\alpha + \beta}{(\beta + w)^2} = -\frac{\tilde{\alpha} - \alpha}{(\tilde{\alpha} - w)^2} < 0 \quad (13)$$

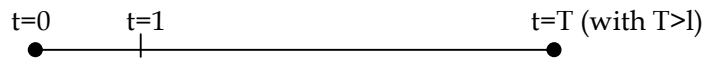
Eq. 12 shows that the rate of return to education is a decreasing function of the relative wage of unskilled workers. Thus, an increase in the relative wage lowers the returns to education for all skilled workers and the incentive for new entrants to become skilled.

### 2.2.2. Investment in Formal Education and Age

Under this framework, in equilibrium individuals will undertake educational training before starting to work. All individuals with  $T$  periods to go until the end of their working life and a level of ability higher than  $\tilde{\alpha}(t=0)$ , will invest in education immediately. It is not rational to postpone this investment. However, an exogenous change in relative wages or in the efficiency of the educational sector will change the returns to schooling. This will affect not only those who are at the beginning of their career but also those already working as unskilled. Under the possibility of reversing the decision of staying unskilled we have to model the decision of becoming skilled for those that are no longer in the beginning of their working life. That is what we do in this section.

In the previous case we assumed that individuals only differ in terms of their level of ability. In the present section we introduce age differences.

If we consider  $t$  to be the age of the individual at a particular point in time (normalised to  $t=0$  when the compulsory stages of educational training ends), in the population there will be people aged between  $0$  and  $T$ . Assuming that age is uniformly distributed within the population, we will have the same number of individuals at each point of the following segment



We assume that at any time in life an individual can reverse his/her initial decision of not becoming skilled.

For any combination of  $t$  and  $\alpha$ , the expected net returns to education are  $R(\alpha, t)$ :

$$R(\alpha, t) = \int_{t+E}^T (\alpha W_S - W_L) e^{-r(z-t)} dz - \int_t^{t+E} (\beta W_S + W_L) e^{-r(z-t)} dz \quad (14)$$

They are positive for

$$\alpha > \tilde{\alpha}(t) = \frac{e^{rT} (e^{rE} - 1)}{e^{rT} - e^{r(t+E)}} \beta + \frac{e^{rE} (e^{rT} - e^{rt}) W_L}{e^{rT} - e^{r(t+E)} W_S} = \Lambda \beta + (1 + \Lambda) w \quad (15)$$

with  $t \neq T - E$  and  $\Lambda = \frac{e^{rT} (e^{rE} - 1)}{e^{rT} - e^{r(t+E)}}$ <sup>7</sup>

Note that, for  $t < T - E$ ,  $\Lambda > 0$ . Moreover, for  $\tilde{\alpha}(t) > 0$  and  $t > 0$ ,  $\Lambda > \Gamma$  thus  $\tilde{\alpha}(t) > \tilde{\alpha}$ .

Accounting for age, the critical level of ability will differ between individuals.  $\tilde{\alpha}(t)$  is a positive function of  $t$ .

$$\frac{\partial \tilde{\alpha}(t)}{\partial t} = \frac{e^{r(E+t+T)} (e^{rE} - 1) r (\beta + w)}{(e^{rT} - e^{r(t+E)})^2} > 0 \quad (16)$$

Accordingly, the older the individual, the higher the minimum level of ability necessary for having positive net returns on the investment in education.

As for  $E > 0$ ,  $\Lambda > 0$ , changes in relative wages of unskilled labour will affect positively the equilibrium level of critical level of ability:

$$\frac{\partial \tilde{\alpha}(t)}{\partial w} = 1 + \Lambda > 0 \text{ for } t < T - E \quad (17a)$$

$$\varepsilon_{\tilde{\alpha}(t), w} = \frac{1}{\frac{\Lambda}{1 + \Lambda} \frac{\beta}{w} + 1} < 1 \quad (17b)$$

Eq. 17a shows that the lower the relative wage of low skilled-labour ( $w$ ), the lower the ability level at which workers are indifferent between entering the labour market immediately or engaging in further educational training. Conversely, the higher the relative wage of low skilled-labour, the higher the number of (potential and

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<sup>7</sup> Note that for  $t=0$ ,  $\Lambda = \Gamma$ .

effective) low-skill workers in each age group that decide not to acquire human capital through additional schooling.

From Eq. 17a combined with Eq. 17b, we can conclude that, everything else being equal, an increase in the relative wage of unskilled labour will increase  $\tilde{\alpha}(t)$  but less than proportionally.

Furthermore, it is important to notice that  $\varepsilon_{\tilde{\alpha}(t),w} < \varepsilon_{\tilde{\alpha},w}$  [see Eq. 17b and Eq. 9b]. The impact of the same change in relative wages on the decision to become a skilled worker varies across age profiles. Fewer individuals belonging to older generations (relative to younger generations) will have an incentive to reverse their prior decision as a consequence of a change in relative wages.

By computing  $\tilde{\alpha}(t)$  it is possible to distinguish individuals of different age profiles that have an incentive to become skilled from those that stay unskilled. Allowing individuals to reverse their decision of not becoming skilled, the question of how big are the relative earnings of those that became skilled at  $t \neq 0$  arises. By computing  $r_E(\alpha, t)$  [Eq. 18] it is possible to address this issue.

$$r_E(\alpha, t) = \frac{\int_{t+E}^T (\alpha W_S - W_L) e^{-r(z-t)} dz}{\int_t^{t+E} (\beta W_S + W_L) e^{-r(z-t)} dz} = \frac{e^{rT} - e^{r(t+E)}}{e^{rT} (e^{rE} - 1)} \frac{\alpha - w}{\beta + w} = \frac{1}{\Lambda} \frac{\alpha - w}{\beta + w} \quad (18)$$

with

$$\frac{\partial r_E(\alpha, t)}{\partial \alpha} = \frac{1}{\Lambda} \frac{1}{\beta + w} > 0 \quad (19)$$

$$\frac{\partial r_E(\alpha, t)}{\partial t} = \frac{e^{r(t+E)}}{e^{rT} (e^{rE} - 1)} \frac{w - \alpha}{w + \beta} r < 0 \text{ for } \alpha > \tilde{\alpha} \quad (20)$$

Eq. 19 shows that among skilled workers of the same age, the higher the level of ability, the higher the rate of return to investment in education. More importantly, among equally able skilled workers, the higher the age at which they decide to invest in education, the lower the rate of return to the investment [Eq. 20].

### 2.3. Factor Endowments in Steady-State

Assuming that at each point in time an exogenous number of individuals  $N_0$  are born and die (the country's population level is stationary), the population

level at  $t$  is equal to  $T * N_0 = N$ . Furthermore, we are also assuming that each individual is replaced by an identical one in terms of ability upon death (the number of individuals with the same level of ability in the population is also stationary).

Thus,  $\tilde{\alpha} N$  individuals constitute the supply of unskilled labour. The remaining  $(1 - \tilde{\alpha})N$  are either:

- Skilled:  $(1 - \tilde{\alpha})(T - E)N_0 = (1 - \tilde{\alpha})(1 - \frac{E}{T})N$

- In educational training in order to become skilled:

$$(1 - \tilde{\alpha})EN_0 = (1 - \tilde{\alpha})\frac{E}{T}N.$$

The average level of ability of individuals that decide to become skilled is  $\tilde{\alpha} + \frac{1 - \tilde{\alpha}}{2} = \frac{1 + \tilde{\alpha}}{2}$ . Therefore, the supply of unskilled and skilled labour are, respectively:

$$L = \tilde{\alpha}N \tag{21}$$

$$S = \frac{1}{2}(1 + \tilde{\alpha})(1 - \tilde{\alpha})(1 - \frac{E}{T})N = \frac{1}{2}(1 - \tilde{\alpha}^2)(1 - \frac{E}{T})N \tag{22}$$

Not all skilled labour services will be used in production of goods.  $\beta$  units of skilled labour are allocated to each student. Therefore, the number of units of skill allocated to education is  $S_E = \beta(1 - \tilde{\alpha})\frac{E}{T}N$ . The number of units of skill diverted to production is  $S_M = S - S_E = \frac{1}{2}(1 - \tilde{\alpha}^2) \left[ 1 - \frac{E}{T} \left( 1 + \frac{2\beta}{1 - \tilde{\alpha}} \right) \right] N$ .

## 2.4. An Unexpected Trade Liberalisation in an H-O-S Setting

### 2.4.1. Trade Driving Forces

In the context of this model trade is motivated by differences between countries in relative factor endowments:  $\frac{S_M}{L}$ . These are endogenous.

They can be motivated by:

- differences in life expectancies and birth rates,

- differences in the efficiency of the educational sector,
- differences in the duration of the additional schooling period needed to become skilled.

Consider the first case. Assume that both countries are similar in size (the population level,  $N$ , is equal in both countries) however, all the rest equal, they differ both in terms of life expectancy and birth rate<sup>8</sup>. In country A life expectancy is higher and birth rate lower than in country B ( $T_A > T_B$  and  $(N_0)_A < (N_0)_B$  with  $T_A^*(N_0)_A = T_B^*(N_0)_B = N$ ).

As,  $\frac{\partial \tilde{\alpha}}{\partial T} < 0$ <sup>9</sup> the difference in life expectancy will imply differences in the critical level of ability between countries:  $\tilde{\alpha}_A < \tilde{\alpha}_B$ . Thus, the supply of unskilled labour is lower in country A than in B and the supply of skilled labour for use in manufacturing (negative function of  $\tilde{\alpha}$  and a positive function of  $T$ <sup>10</sup>) is higher in country A than in B.

In steady state differences in endowments will exist between countries:

	L	S <sub>M</sub>
Country A	$\tilde{\alpha}_A N$	$\frac{1}{2}(1 - \tilde{\alpha}_A^2) \left[ 1 - \frac{E}{T} \left( 1 + \frac{2\beta}{1 - \tilde{\alpha}_A} \right) \right] N$
Country B	$\tilde{\alpha}_B N$	$\frac{1}{2}(1 - \tilde{\alpha}_B^2) \left[ 1 - \frac{E}{T} \left( 1 + \frac{2\beta}{1 - \tilde{\alpha}_B} \right) \right] N$

Country A will be the skill abundant country and country B the unskilled labour abundant country,  $\left( \frac{S_M}{L} \right)_A > \left( \frac{S_M}{L} \right)_B$ .

Let's examine the second case, in which the only difference between countries is in the efficiency of the educational sector. Assume that everything else equal, the

<sup>8</sup> Note that in the context of this model birth rate equals death rate.

<sup>9</sup> Note that  $\frac{\partial \tilde{\alpha}}{\partial T} = - \frac{e^{r(t+T+E)}(e^{rE} - 1)}{(e^{rT} - e^{rE})^2} r(w + \beta)$ .

<sup>10</sup> Note that  $\frac{\partial S_M}{\partial \tilde{\alpha}} = - \frac{\alpha(T-E) + \beta E}{T} N < 0$  and  $\frac{\partial S_M}{\partial T} = \frac{N(1+\alpha)[1 - (\alpha - 2\beta)]E}{2T^2} > 0$ .



efficiency of the educational sector is higher A than in B ( $\beta_A < \beta_B$ ). As,  $\frac{\partial \tilde{\alpha}}{\partial \beta} > 0$ <sup>11</sup>, the difference in the efficiency of the educational sector will imply differences in the critical level of ability between countries:  $\tilde{\alpha}_A < \tilde{\alpha}_B$ . Therefore, as in the previous case  $\left(\frac{S_M}{L}\right)_A > \left(\frac{S_M}{L}\right)_B$ <sup>12</sup>.

Finally, let's examine the third case, in which the only difference between the two countries is in the duration of the educational process that being skilled involves. Assume that everything else being equal, it is higher in country B than in country A ( $E_A < E_B$ ). As,  $\frac{\partial \tilde{\alpha}(t)}{\partial E} > 0$ <sup>13</sup>, like in the two previous cases  $\tilde{\alpha}_A < \tilde{\alpha}_B$ . Therefore, country A will be the skill abundant country and country B the unskilled labour abundant country<sup>14</sup>,  $\left(\frac{S_M}{L}\right)_A > \left(\frac{S_M}{L}\right)_B$ .

#### 2.4.2. Trade Expansion Effects in the Skill Abundant Country

Considering two countries that only differ in the ratio:  $\frac{S_M}{L}$ . By the Heckscher-Ohlin and Stolper-Samuelson theorems, trade will induce a decrease in the relative price of the skill-intensive good in the low-skill abundant country (in the other country, the opposite occurs). Furthermore, if changes in prices induce changes in factor supplies, the combined price elasticity of supply will be made higher (Rybczynski effect).

Let's specifically analyse the effects of trade expansion in each country.

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<sup>11</sup> Note that  $\frac{\partial \tilde{\alpha}}{\partial \beta} = \frac{e^{rT}(e^{rE} - 1)}{e^{rT} - e^{rE}}$ .

<sup>12</sup> Note that  $\frac{\partial S_M}{\partial \beta} = -\frac{(1+\alpha)E}{T} N < 0$

<sup>13</sup> Note that  $\frac{\partial \tilde{\alpha}(t)}{\partial E} = \frac{e^{r(T+E)}(e^{rT} - e^{rt})}{[e^{rT} - e^{r(t+E)}]^2} r(w + \beta)$ , with  $t=0$ :  $\frac{\partial \tilde{\alpha}}{\partial E} = \frac{e^{r(T+E)}(e^{rT} - 1)}{(e^{rT} - e^{rE})^2} r(w + \beta)$ .

<sup>14</sup> Note that  $\frac{\partial S_M}{\partial E} = -\frac{(1+\alpha)[1-(\alpha-2\beta)]}{2T} N < 0$

In the skill abundant country, trade liberalisation induces an increase in the relative price of the skill intensive good. Hence, by the Stolper-Samuelson theorem, trade liberalisation reduces  $W_L$  and increases  $W_S$ . Therefore, the wage rate for skilled workers in the post-trade liberalisation steady-state ( $W_S'$ ) will be higher than that of the initial (pre-trade liberalisation) steady-state ( $W_S$ ):  $W_S' > W_S$ . Conversely, the wage rate for unskilled workers in the post-trade liberalisation steady-state ( $W_L'$ ) will be lower than of the initial (pre-trade liberalisation) steady-state ( $W_L$ ):  $W_L' < W_L$ . Thus, the relative wage rate of unskilled labour will decrease  $\left[ \frac{W_L'}{W_S'} = w' < w = \frac{W_L}{W_S} \right]$ .

At the time of trade liberalisation there are three types of individuals in the working age population: unskilled workers, students, and skilled workers. First, unskilled workers differ on the time they are already working. They all have  $T-t$  periods to go until the end of their career but  $t$  differs among them. On the other hand, students differ on the time already spent in schooling. However, they all have  $T-t > T-E$  periods to go until the end of their working life. Finally, there are individuals working as skilled having  $T-t < T-E$  periods to go until the end of their career.  $t$  differs among them. Individuals with different age profiles and labour status will have different reactions to trade liberalisation.

#### **2.4.2.1. Winners and Losers from Trade Liberalisation**

##### **(i) The case of unskilled workers**

They all have  $T-t$  periods to go until the end of their career but  $t$  differs among them.

Let's distinguish two groups of unskilled individuals. First, individuals that have just finished the compulsory stages of educational training ( $t=0$ ) and, therefore, have  $T$  working periods to go until the end of their working life. Second, individuals working as unskilled that have  $T-t$  periods to go until the end of their career.

##### *Unskilled workers in the beginning of their career*

They are in the beginning of their working life. With  $T$  periods to go, they will decide whether to enter the labour market immediately as unskilled or engage in further educational training. Their decision is based on post-trade prices.

As shown in Eq. 9a the critical level of ability is a positive function of the relative wage of unskilled labour. By increasing the returns on education, trade creates an additional incentive to become skilled. More individuals in the beginning of their career will opt to engage in further educational training than in previous generations.

Under the pre-trade prices the present value of net returns to education is positive for all individuals with a level of ability in the interval  $[\tilde{\alpha}, 1]$ , under the post-trade prices the present value of net returns to education is positive for all individuals with a level of ability in the interval  $[\tilde{\alpha}_{t=0}', 1]$  with  $\tilde{\alpha}_{t=0}' = \Gamma\beta + (1 + \Gamma)w' < \tilde{\alpha} = \Gamma\beta + (1 + \Gamma)w$ . Therefore, trade will induce individuals with a level of ability in the interval  $[\tilde{\alpha}_{t=0}', \tilde{\alpha}]$  to become skilled instead of staying unskilled.

All the individuals with an ability level in the interval  $[\tilde{\alpha}, 1]$  will benefit from trade liberalisation for two reasons. First, their rate of return on the investment in education is higher than it would have been in the absence of trade liberalisation (see Eq. 13). Second, lifetime earnings are higher than they would have been in the absence of trade liberalisation. Eq. 23 for  $\alpha > \tilde{\alpha}$  and  $W_S' > W_S$ ,

$$\begin{aligned}
LE' - LE &> \frac{e^{rE}(e^{rT} - 1)}{e^{r(T+E)}} \frac{W_L(W_S' - W_S)}{rW_S} > 0 \\
LE' - LE &= \left( \int_E^T \alpha W_S' e^{-rz} dz - \int_0^E \beta W_S' e^{-rz} dz \right) - \left( \int_E^T \alpha W_S e^{-rz} dz - \int_0^E \beta W_S e^{-rz} dz \right) = \\
&= \int_E^T \alpha (W_S' - W_S) e^{-rz} dz - \int_0^E \beta (W_S' - W_S) e^{-rz} dz = \left[ \frac{(e^{rT} - e^{rE})\alpha - e^{rT}(e^{rE} - 1)\beta}{e^{r(T+E)}} \right] \frac{W_S' - W_S}{r}
\end{aligned} \tag{23}$$

where  $LE$  and  $LE'$  are, respectively, the life-time earnings pre- and post-liberalisation.

Those with an ability level in the interval  $[\tilde{\alpha}_{t=0}', \tilde{\alpha}]$  in the absence of trade liberalisation would have remained unskilled.

Those with an ability level in the interval  $[\tilde{\alpha}_{t=0}', \tilde{\alpha}]$  in the absence of trade liberalisation would have remained unskilled.

$$\begin{aligned}
LE' - LE &= \left( \int_E^T \alpha W_S' e^{-rz} dz - \int_0^E \beta W_S' e^{-rz} dz \right) - \int_0^T W_L e^{-rz} dz = \\
&= \frac{(e^{rT} - e^{rE})W_S' \alpha - e^{rT} (e^{rE} - 1)W_S' \beta - e^{rE} (e^{rT} - 1)W_L}{e^{r(T+E)} r} \tag{24} \\
LE' - LE &= 0 \text{ when } \alpha = \tilde{\alpha} + (1 + \Gamma)w \left( \frac{W_S}{W_S'} - 1 \right) = \tilde{\alpha}' + (1 + \Gamma)w' \left( \frac{W_L}{W_L'} - 1 \right) \\
\text{and } \frac{\partial(LE' - LE)}{\partial \alpha} &> 0
\end{aligned}$$

Eq. 24 suggests that in this country, although as a consequence of trade liberalisation they prefer to become skilled instead of remaining unskilled, only the more able will benefit from trade liberalisation. Only for those, not only are post-trade life-time earnings as skilled higher than post-trade life-time earnings as unskilled, but also, higher than pre-trade lifetime earnings as unskilled.

#### *Individuals working as unskilled*

For the second type of individual, the situation is different. They observe trade liberalisation after having decided not to invest in education in the beginning of their career. The traditional analysis considers that this type of worker loses as a consequence of trade liberalisation due to the lower wage rate of unskilled labour. However, this does not allow for reversal of the decision of not becoming skilled. This new feature of our framework brings interesting additional insights.

Under post-trade prices, an individual who, given his level of ability at the beginning of his working life, had chosen not to invest in education can regret the decision made when younger. Moreover, he/she will have to decide between going back to school in order to change occupation and remaining unskilled. Changing occupation implies educational training for  $E$  periods.

Had an unskilled worker decided to become skilled in the beginning of his/her career and his/her net discounted benefits of the investment in education, under the post trade prices after time  $t$ , would have been<sup>15</sup>:

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<sup>15</sup> Note that we are considering that all unskilled workers have more than  $E$  years of experience. To see what the particular case of those with a level of experience lower than  $E$  go to appendix 1.

$$R(\alpha)' = \left[ \int_E^t (\alpha W_S - W_L) e^{-rz} dz + \int_t^T (\alpha W_S' - W_L') e^{-rz} dz \right] - \int_0^E (\beta W_S + W_L) e^{-rz} dz \quad (25)$$

They are positive for  $\alpha > \tilde{\alpha}'$  with

$$\tilde{\alpha}' = \frac{e^{r(t+T)}(e^{rE} - 1)W_S}{e^{rT}(e^{rt} - e^{rE})W_S + e^{rE}(e^{rT} - e^{rt})W_S'} \beta + \frac{e^{r(E+T)}(e^{rt} - 1)W_L + e^{rE}(e^{rT} - e^{rt})W_L'}{e^{rT}(e^{rt} - e^{rE})W_S + e^{rE}(e^{rT} - e^{rt})W_S'} \quad (26)$$

As  $R(\alpha)' > R(\alpha)^{16}$ ,  $\tilde{\alpha}' < \tilde{\alpha}$ . Thus, in every generation, the unskilled workers with a level of ability in the interval  $[\tilde{\alpha}', \tilde{\alpha}]$  have lower working earnings than those they could have given their ability level.

The fact that unskilled workers with a level of ability in the interval  $[\tilde{\alpha}', \tilde{\alpha}]$  regret their decision of not becoming skilled, *per se*, is not an adjustment cost. These workers can reverse their previous decision and invest in education. However, only those that expect net benefits from investing on education at  $t$  will do it.

Given the worker's age, he/she will find it profitable to engage in further education at age  $t$  if  $R(\alpha, t)$  [given by Eq. 14 with  $W_L = W_L'$  and  $W_S = W_S'$ <sup>17</sup>] is higher than 0. Therefore, if he/she has a level of ability within the interval  $[\tilde{\alpha}(t)', \tilde{\alpha}]$ , with  $\tilde{\alpha}(t)' = \lambda\beta + (1 + \lambda)\frac{W_L'}{W_S'}$ ; he/she will decide to change occupation through educational training<sup>18</sup>.

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<sup>16</sup> Note that  $R(\alpha)' = R(\alpha) + \int_t^T [(W_L - W_L') - (W_S - W_S')\alpha] e^{-rz} dz$ .

Moreover,  $\forall \alpha, \int_t^T [(W_L - W_L') - (W_S - W_S')\alpha] e^{-rz} dz = \frac{(e^{rT} - e^{rt})[(W_L - W_L') - (W_S - W_S')\alpha]}{e^{r(t+T)}r} > 0$  for  $W_L > W_L'$

and  $W_S < W_S'$ . Thus,  $\forall \alpha, R(\alpha)' > R(\alpha)$  in the skill abundant country.

<sup>17</sup>  $R(\alpha, t)' = \int_{t+E}^T (\alpha W_S' - W_L') e^{-r(z-t)} dz - \int_t^{t+E} (\beta W_S' + W_L') e^{-r(z-t)} dz < R(\alpha)'_{t < E} < R(\alpha)'_{t > E}$

<sup>18</sup> Note that for  $t \geq T - E$  it is never rational to change occupation because there wouldn't be returns on the investment needed.

$\tilde{\alpha}(t)'$  is always lower than  $\tilde{\alpha}$  for  $t < T + \frac{1}{r} \ln[Z]$  with

$$Z = \frac{W_L - W_L'}{\alpha W_S' - W_L'} \left( \frac{e^{rT} - 1}{e^{rT}} \right) + \frac{W_S' - W_S}{\alpha W_S' - W_L'} \left( \frac{e^{rT} - e^{rE}}{e^{r(E+T)}} \alpha - \frac{e^{rE} - 1}{e^{rE}} \beta \right) + \frac{1}{e^{rT}}.^{19}$$

Thus, in all generations until  $t = T + \frac{1}{r} \ln[Z]$  there will be unskilled workers that decide to change occupation though educational training.

Under this setting, there are three cases to be considered. Either  $\tilde{\alpha}' < \tilde{\alpha}(t)' < \tilde{\alpha}$ ,  $\tilde{\alpha}(t)' < \tilde{\alpha}' < \tilde{\alpha}$  and  $\tilde{\alpha}' < \tilde{\alpha} \leq \tilde{\alpha}(t)'$  with the particular ordering depending upon the underlying parameters of the model.

Let's consider the first case (illustrated in figures 2). Given their level of ability, unskilled workers aged  $t \neq 0$  can be in one of the following situations.

First, those with a level of ability in the interval  $[0, \tilde{\alpha}']$  choose to remain unskilled. They will lose as a consequence of trade liberalisation. Their lifetime

discounted (to  $t=0$ ) earnings will equal  $\left( \int_0^t W_L e^{-rt} + \int_t^T W_L' e^{-rt} \right)$ , lower than  $\int_0^T W_L e^{-rt}$ .

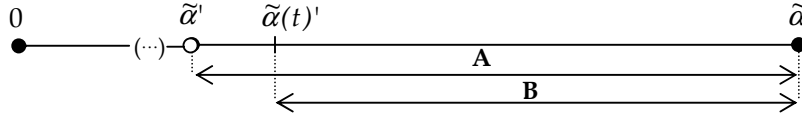
All remaining unskilled workers regret their initial decision of not becoming skilled [segment A]. However, only the more able of those will reverse it [segment B]. Thus, individuals with a level of ability in the interval  $[\tilde{\alpha}', \tilde{\alpha}(t)']$  will suffer two types of losses from trade liberalisation. First, a cost in terms of resources: lower lifetime discounted earnings as unskilled workers. Second, a psychological cost: earnings below their potential level considering the possessed level of ability. They will have to cope with frustration of regretting the decision made when younger, knowing that it is too late to reverse it.

Third, individuals with a level of ability in the interval  $[\tilde{\alpha}(t)', \tilde{\alpha}]$  will decide to change occupation through educational training from age  $t$  until  $t+E$ .

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<sup>19</sup> To see the mathematical proof go to Appendix 2.

**Figure 2 - Unskilled labour: Regrets versus Reversals**



However, it is interesting to notice they will have rates of return on the investment in education lower than their potential level (considering their level of ability). Given the post-trade prices, schooling early in their lives would have a higher rate of return on the investment. In fact, the period of return to the investment in education is shorter if it just occurs after trade liberalisation. Later investments produce returns over a shorter period, thus postponement of the investment reduces the present value of net gains. Moreover, direct education costs will be higher after trade liberalisation.

For these workers the actual rate of return on education  $[r_E(\alpha, t)']$  given by Eq. 18 with  $W_L = W_L'$  and  $W_S = W_S'$  ] is lower than if they had decided to become skilled workers at the beginning of their careers (when they had  $T$  working life periods to go)  $[r_E(\alpha)']$ .

$$r_E(\alpha)' = \frac{\int_0^t (\alpha W_S - W_L) e^{-rz} dz + \int_t^T (\alpha W_S' - W_L') e^{-rz} dz}{\int_0^E (\beta W_S + W_L) e^{-rz} dz} \quad (27a)$$

$$r_E(\alpha, t)' = \frac{\int_t^T (\alpha W_S' - W_L') e^{-r(z-t)} dz}{\int_t^{t+E} (\beta W_S' + W_L') e^{-r(z-t)} dz} \quad (27b)$$

with  $\alpha \in ]\tilde{\alpha}', \tilde{\alpha}(t)']$ ,  $r_E(\alpha)' > 1$  and  $r_E(\alpha, t)' < 1$  therefore we have  $r_E(\alpha, t)' < r_E(\alpha)$ .

Moreover, even though all the more able unskilled workers (individuals with a level of ability in the interval  $]\tilde{\alpha}(t)', \tilde{\alpha}]$ ), have positive net returns on education, not all will benefit from trade liberalisation.

$$\begin{aligned}
LE'-LE &= \left( \int_{t+E}^T \alpha W_S' e^{-rz} dz - \int_t^{t+E} \beta W_S' e^{-rz} dz \right) - \int_t^T W_L e^{-rz} dz = \\
&= \frac{(e^{rT} - e^{r(t+E)}) W_S' \alpha - e^{rT} (e^{rE} - 1) W_S' \beta - e^{rE} (e^{rT} - e^{rt}) W_L}{e^{r(T+t+E)} r} \\
LE'-LE = 0 \text{ when } \alpha &= \frac{e^{rT} (e^{rE} - 1)}{e^{rT} - e^{r(t+E)}} \beta + \frac{e^{rE} (e^{rT} - e^{rt})}{e^{rT} - e^{r(t+E)}} \frac{W_L}{W_S'} = \\
&= \underbrace{\tilde{\alpha}(t)' + (1 + \Lambda) w' \left( \frac{W_L}{W_S'} - 1 \right)}_{> \tilde{\alpha}(t)'} + \underbrace{\tilde{\alpha}(t) + (1 + \Lambda) w \left( \frac{W_S'}{W_S'} - 1 \right)}_{< \tilde{\alpha}(t)}
\end{aligned} \tag{28}$$

$$\text{and } \frac{\partial (LE'-LE)}{\partial \alpha} > 0$$

For workers with an ability level equal to  $\tilde{\alpha}(t)'$ , life-time earnings post-trade liberalisation are lower than life-time earnings pre-trade liberalisation. Moreover, if

$$\beta > \left( \frac{1 + \Gamma}{W_S} - \frac{1 + \Lambda}{W_S'} \right) \frac{W_L}{\Lambda - \Gamma} = \left( \frac{(e^{rT} - 1)(e^{rT} - e^{r(t+E)})}{W_S} - \frac{(e^{rT} - e^{rt})(e^{rT} - e^{rE})}{W_S'} \right) \frac{W_L}{e^{rT} (e^{rT} - 1)(e^{rE} - 1)}$$

then, all the unskilled workers that decide to change their course of action through educational training will be losers of trade liberalisation ( $\forall \alpha, \alpha \in [\tilde{\alpha}(t)', \tilde{\alpha}]$ ,  $LE'-LE < 0$ ). Otherwise, the more able of them, and only those, may win as a consequence of trade liberalisation as for  $\tilde{\alpha}$ ,  $LE'-LE > 0$ . Note that, in any case, those who lose, lose less than any worker with an ability level lower than theirs.

Our framework also allows us to analyse if there are inter-generational differences in the number of unskilled workers in each of the situations.  $\tilde{\alpha}$  does not depend on age. However,  $\tilde{\alpha}'$  and  $\tilde{\alpha}(t)'$  do.

$$\begin{aligned}
\frac{\partial \tilde{\alpha}'}{\partial t} &= \frac{r(W_L - W_L') \left[ (e^{-rE} - e^{-rt}) W_S + (e^{-rt} - e^{-rT}) W_S' \right]}{e^{rt} \left[ (e^{-rE} - e^{-rt}) W_S + (e^{-rt} - e^{-rT}) W_S' \right]^2} - \\
&- \frac{r(W_S - W_S') \left[ (e^{-rE} - e^{-rt}) W_L + (e^{-rt} - e^{-rT}) W_L' + (1 - e^{-rE})(W_L + W_S \beta) \right]}{e^{rt} \left[ (e^{-rE} - e^{-rt}) W_S + (e^{-rt} - e^{-rT}) W_S' \right]^2} > 0
\end{aligned} \tag{29a}$$

$$\frac{\partial \tilde{\alpha}'(t)}{\partial t} = \frac{e^{r(E+t+T)} (e^{rE} - 1) r (W_S' \beta + W_L')}{(e^{rT} + e^{r(t+E)})^2} > 0$$



$$\frac{\partial \left[ \frac{\partial \tilde{\alpha}'}{\partial t} \right]}{\partial t} < 0 \quad (29b)$$

$$\frac{\partial \left[ \frac{\partial \tilde{\alpha}'(t)}{\partial t} \right]}{\partial t} = \frac{e^{r(t+T+E)}(e^{rT} - e^{r(T+E)})r^2(W_L' + W_S'\beta)}{(e^{rT} + e^{r(t+E)})^3} > 0$$

Eqs. 29a show that  $\tilde{\alpha}'(t)$  is always a positive function of age and, in the skill abundant country,  $\tilde{\alpha}'$  is also a positive function of  $t$ . Therefore, the higher the age profile, the larger the number of individuals that cannot escape wage losses due to trade liberalisation through occupational change.

Eqs. 29b show that  $\tilde{\alpha}'(t)$  is concave while  $\tilde{\alpha}'$  is convex. Therefore, until a certain age level each additional year has a bigger impact on  $\tilde{\alpha}'(t)$  than on  $\tilde{\alpha}'$  after which the opposite happens. Under this setting, in younger generations, the higher the age profile, the larger the number of individuals that although regretting their previous decision regarding educational training, know that it is too late to reverse it.

The second possibility is that  $\tilde{\alpha}'(t) < \tilde{\alpha}' < \tilde{\alpha}$ . In this case although trade liberalisation does not induce regrets, there will be reversals. Unskilled workers with an ability level in the interval  $[\tilde{\alpha}'(t), \tilde{\alpha}]$  will change their labour status through education. Moreover, as  $\tilde{\alpha}'(t)$  is a positive function of age, the number of workers that do so is lower in older generations. Therefore, the severity of the losses induced by trade is higher for older generations.

Finally, if  $\tilde{\alpha}' < \tilde{\alpha} \leq \tilde{\alpha}'(t)$ , trade liberalisation does not induce regrets nor does it lead to moves between occupations. Therefore, all the unskilled workers will face wage losses as a consequence of trade liberalisation. Note that this can only be the case of workers that at time of trade liberalisation are aged  $T + \frac{1}{r} \ln[Z]$  with

$$Z = \frac{W_L - W_L'}{\alpha W_S' - W_L'} \left( \frac{e^{rT} - 1}{e^{rT}} \right) + \frac{W_S' - W_S}{\alpha W_S' - W_L'} \left( \frac{e^{rT} - e^{rE}}{e^{r(E+T)}} \alpha - \frac{e^{rE} - 1}{e^{rE}} \beta \right) + \frac{1}{e^{rT}}$$

it is only possible for those to have  $\tilde{\alpha} \leq \tilde{\alpha}'(t)$ .

**(ii) The case of students**

As a consequence of trade liberalisation the discounted benefits of the investment in education increase: the positive difference between earnings of skilled workers relative to unskilled workers increases. The effect on discounted costs is less clear. Higher tuition fees make discounted costs higher. Lower forgone earnings make discounted costs lower.

The actual discounted value of net returns of students [ $R(\alpha)'_{t<E}$ ] (discounted for  $t=0$ ) is

$$R(\alpha)'_{t<E} = \int_E^T (\alpha W_S' - W_L') e^{-rz} dz - \left[ \int_0^t (\beta W_S + W_L) e^{-rz} dz + \int_t^E (\beta W_S' + W_L') e^{-rz} dz \right] \quad (30)$$

where  $t$  is the age of the individual at the time of trade liberalisation.

Eq. 31 gives the difference between the actual and the expected discounted value of the net returns [ $R(\alpha)$  was defined in Eq. 7]<sup>20</sup>:

$$\begin{aligned} R(\alpha)'_{t<E} - R(\alpha) &= \\ &= \int_E^T [\alpha(W_S' - W_S) - (W_L' - W_L)] e^{-rz} dz - \int_t^E [\beta(W_S' - W_S) + (W_L' - W_L)] e^{-rz} dz = \\ &= \int_t^T (W_L - W_L') e^{-rz} dz + (W_S' - W_S) \left( \int_E^T \alpha e^{-rz} dz - \int_t^E \beta e^{-rz} dz \right) \end{aligned} \quad (31)$$

In the skill abundant country  $R(\alpha)'_{t<E} > R(\alpha)$  for all students (the proof is presented on Appendix 3). Thus, the increase in the future benefits of being skilled more than compensate the increase in tuitions fees while a student. As a consequence of trade liberalisation students do not regret their decision of investing in education, the associated returns became even higher than initially expected. The increase in the returns on education is the benefit of trade liberalisation for these individuals<sup>21</sup>.

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<sup>20</sup> Note that all students have  $\alpha > \tilde{\alpha}$  thus  $R(\alpha) > 0$ . Thus if we have  $R(\alpha)'_{t<E} - R(\alpha) > 0$  for all  $\alpha > \tilde{\alpha}$ , it must be the case that  $R(\alpha)'_{t<E} > R(\alpha)$ .

<sup>21</sup> It equals the increase in student's life-time earnings.

One important result of our framework is that not all students have equal benefits. They differ on the remaining time they have to spent on the educational system in order to become skilled and, therefore, on the actual of rate of return on the investment in education [ $r_E(\alpha)'_{t < E}$ ].

$$\begin{aligned}
r_E(\alpha)'_{t < E} &= \frac{\int_0^T (\alpha W_S' - W_L') e^{-rz} dz}{\int_0^t (\beta W_S + W_L) e^{-rz} dz + \int_t^E (\beta W_S' + W_L') e^{-rz} dz} = \\
&= \frac{e^{rt} (e^{rT} - e^{rE}) (W_S' \alpha - W_L')}{e^{r(T+E)} (e^{rt} - 1) (W_L + W_S \beta) + e^{rT} (e^{rE} - e^{rt}) (W_L' + W_S' \beta)} = \\
&= \frac{(W_S' \alpha - W_L')}{\frac{(e^{r(t+T+E)} - e^{r(T+E)})}{(e^{r(T+t)} - e^{r(E+t)})} (W_L + W_S \beta) + \frac{(e^{r(E+T)} - e^{r(t+T)})}{(e^{r(T+t)} - e^{r(E+t)})} (W_L' + W_S' \beta)} = \\
&= \frac{e^{-rT} (e^{r(T+t)} - e^{r(E+t)}) (W_S' \alpha - W_L')}{\left[ e^{rt} (e^{rE} W_S - W_S') + e^{rE} (W_S' - W_S) \right] \beta + \left[ e^{rE} e^{rt} - e^{rE} \right] W_L + (e^{rE} - e^{rt}) W_L'}
\end{aligned} \tag{32}$$

$$\begin{aligned}
\frac{\partial r_E(\alpha)'_{t < E}}{\partial t} &= \\
&= \frac{r e^{r(t+E)} (e^{rT} - e^{rE})}{e^{rT}} \frac{(W_S' \alpha - W_L') [(W_L' - W_L) + (W_S' - W_S) \beta]}{\left[ e^{rE} (1 - e^{rt}) (W_L + W_S \beta) + (e^{rt} - e^{rE}) (W_L' + W_S' \beta) \right]^2}
\end{aligned} \tag{33}$$

As  $\alpha > \tilde{\alpha} > \frac{W_L}{W_S} > \frac{W_L'}{W_S'}$  for all the students,  $(W_S' \alpha - W_L') > 0$ . Thus, the actual rate of return on the investment in education is a positive function of  $t$  for  $\beta > -\frac{\Delta W_L}{\Delta W_S} = \frac{W_L' - W_L}{W_S - W_S'}$ .<sup>22</sup> In this case, students closer to the end of the educational process will have a higher benefit from trade liberalisation than their younger counterparts as the positive difference between the post- and the pre-trade trade rate of return of their investment in education is larger. The converse is valid for  $\beta < -\frac{\Delta W_L}{\Delta W_S}$ .

<sup>22</sup>  $\lim_{t \rightarrow 0} r_E(\alpha)' = \frac{1}{\Gamma} \frac{W_S' \alpha - W_L'}{W_S' \beta + W_L'} = \frac{1}{\Gamma} \frac{\alpha - w'}{\beta + w'} > r_E(\alpha)$  and

$\lim_{t \rightarrow E} r_E(\alpha)'_{t < E} = \frac{1}{\Gamma} \frac{W_S' \alpha - W_L'}{W_S \beta + W_L} = \frac{1}{\Gamma} \frac{\alpha - w'}{\beta + w'} \frac{W_S' \beta + W_L'}{W_S \beta + W_L}$ .

### (iii) The case of skilled workers

This type of worker has capital gains as a consequence of trade liberalisation. By increasing the wage rate of skilled labour and decreasing the wage rate of unskilled labour, trade liberalisation increases the discounted benefits of investment in education. In contrast to the situation of students, it does not affect the costs of schooling, only the benefits. The actual rate of return on the investment in education [ $r_E(\alpha)'$ : see Eq. 27a] is higher than it would have been in the absence of trade liberalisation:

$$r_E(\alpha)' - r_E(\alpha) = \frac{(e^{rT} - e^{rt})}{e^{r(T+t-E)}(e^{rE} - 1)} \frac{(W_L - W_L') + (W_S' - W_S)\alpha}{(W_L + W_S)\beta} > 0 \quad (34)$$

However, not all skilled workers have equal benefits. They differ on the length of their remaining working life and therefore on the actual rate of return on the investment in education. Eq. 35 shows that, under our framework, the higher the age, the lower the gains induced by trade liberalisation.

$$\frac{\partial [r_E(\alpha)' - r_E(\alpha)]}{\partial t} = \frac{\partial r_E(\alpha)'}{\partial t} = -\frac{r(W_L - W_L') + (W_S' - W_S)\alpha}{e^{r(t-E)}(e^{rE} - 1)(W_L + W_S)\beta} < 0 \quad (35)$$

#### 2.4.2.2. Factor Endowments in the New Steady-State

Under our framework, trade in the skill abundant country leads to an increase in the return to education. As a consequence the equilibrium level of the critical level of ability decreases leading to an increase in the number of skilled workers and to a narrowing in the number of unskilled workers.

The new equilibrium supply of skilled and unskilled labour is given by Eq. 21 and Eq. 22 with  $\tilde{\alpha} = \tilde{\alpha}_{t=0}'$ , where  $\tilde{\alpha}_{t=0}'$  is the critical level of ability in the new steady state [Eq. 8 with  $W_S = W_S'$  and  $W_L = W_L'$ :  $\tilde{\alpha}_{t=0}' = \frac{e^{rT}(e^{rE} - 1)}{e^{rT} - e^{rE}}\beta + \frac{e^{rE}(e^{rT} - 1)}{e^{rT} - e^{rE}}\frac{W_L}{W_S}$ ].

Thus, the changes in the supply of skilled and unskilled labour are, respectively:

$$L'-L = (\tilde{\alpha}_{t=0}' - \tilde{\alpha})N \quad (36)$$

$$\begin{aligned} S'-S &= \frac{1}{2}[(1 - \tilde{\alpha}_{t=0}'^2) - (1 - \tilde{\alpha}^2)] \left(1 - \frac{E}{T}\right)N = \\ &= (\tilde{\alpha} - \tilde{\alpha}')N \left[\frac{1}{2}(\tilde{\alpha} + \tilde{\alpha}_{t=0}')\left(1 - \frac{E}{T}\right)\right] \end{aligned} \quad (37)$$

Note that more students with the same number of teachers *per student* implies that more units of skill are diverted to education. There is a positive change in the number of units of skilled labour allocated to education equal to:

$$S_E' - S_E = \beta \frac{E}{T} N (\tilde{\alpha} - \tilde{\alpha}_{t=0}') > 0.$$

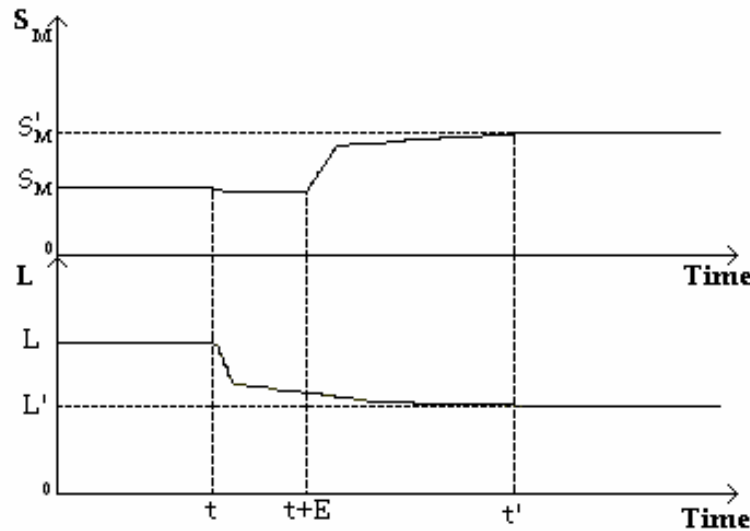
The variation in number of units of skill allocated to

production is equal to:  $S_M' - S_M = (\tilde{\alpha} - \tilde{\alpha}_{t=0}') \left( \frac{1}{2}(\tilde{\alpha} + \tilde{\alpha}_{t=0}') - \left[ \frac{1}{2}(\tilde{\alpha} + \tilde{\alpha}_{t=0}') + \beta \right] \frac{E}{T} \right) N.$

### 2.4.2.3. Dynamics of Labour Supply

Figure 3 depicts the dynamics of unskilled and skilled labour supply for use in manufacturing between the two steady-states in the skilled labour abundant country.

Figure 3 - Dynamics of labour supply skill abundant country



Immediately after trade liberalisation the number of unskilled workers will decrease for two reasons. First, as a consequence of trade liberalisation more individuals in the beginning of their working life choose to engage in further educational training. Second, some unskilled workers decide to change occupation.

This negative change in the unskilled labour supply will imply a positive change in the number of students and, consequently, on the skilled labour services drawn into the education system. However, the total stock of skilled labour will remain at its initial level until  $t+E$ . Notwithstanding this, during this period less skilled labour services will be available for use in production due to the additional needs of education services. Note that as for  $t > T - E$ ,  $\tilde{\alpha}(t)'$  is negative, no unskilled worker with less than time  $E$  to go until the end of his career will invest in education. Therefore, the number of students and, consequently, the need for education services will increase, not only right after  $t$ , but until  $t+E$  - the number of unskilled workers leaving the labour market surpasses the number of unskilled workers arriving to the labour market. Conversely, the quantity of unskilled and skilled labour services available for use in manufacturing decreases.

At  $t+E$ , the unskilled workers that have decided to change occupation will re-enter the labour market as skilled workers. The increase in the number of students at  $t$  will equal the increase in the number of skilled workers at  $t+E$ . Note that the increase in the skilled labour supply of the manufacturing sector will be even higher as the needs for educational services will decrease.

Considering the result that not all individuals with a level of ability higher than  $\tilde{\alpha}_{t=0}'$  (defined on Eq. 8 with  $W_L = W_L'$  and  $W_S = W_S'$ ) will become skilled, the transition between the pre- and post-trade steady-state can take some time. By assuming that each individual is replaced by an identical one in terms of ability upon death, the time transition will take equals  $T$  minus the age of the younger unskilled worker that has a level ability in the interval  $[\tilde{\alpha}_{t=0}', \tilde{\alpha}(t)']$ . During this time, considering the result that  $\tilde{\alpha}(t)'$  is a positive function of age at the time of trade liberalisation ( $t$ ) and that  $\tilde{\alpha}_{t=0}'$  does not depend on  $t$ , the decrease/increase in the supply of unskilled/skilled labour will be increasingly smaller until at  $t'$  the

new steady-state levels of supply of skilled and unskilled labour and students are achieved.

According to the theory on variable factor supplies and H-O-S model (e.g. Martin, 1976; Neary, 1978, Woodland, 1982), provided that factor supplies are not backward-bending and there is incomplete specialisation, there will be a shift to specialisation in the skill-intensive good ( $X_2$ ) in the skill abundant country. This result is consistent with the findings of Borsook (1987) and Findlay and Kierzkowski (1983). By modelling adjustment, we present news results. In particular, we find that this shift is progressive and has the following dynamics: right after trade liberalisation, both  $L$  and  $S_M$  fall but in different proportions,  $|\Delta L| > |\Delta S_M|$ , producing a Rybczynski negative effect on  $X_1$  and a positive effect on  $X_2$ . After the first impact, and until  $t+E$ , the supply of skilled labour for use in manufacturing remains constant while the supply of unskilled labour falls. This induces a negative effect on  $X_1$  and a positive effect on  $X_2$ . After  $t+E$ , with  $S_M$  in variable supply as well, and a further decrease in  $L$ , there will be a further shift to specialisation in the skill-intensive good. Note that both the rise in  $S_M$  and the fall in  $L$  produce positive Rybczynski effects on  $X_2$  and negative effects on  $X_1$ . This pattern of evolution will continue at a decreasing rhythm until the new steady-state levels of skilled and unskilled labour supplies are achieved.

### **2.4.3. Trade Expansion Effects in the Unskilled Labour Abundant Country**

#### **2.4.3.1. Winners and Losers from Trade Liberalisation**

In this country, trade liberalisation induces a decrease in the relative price of the skill intensive good. Hence, by the Stolper-Samuelson theorem, reduces  $W_S$  (the return of skill) and increases  $W_L$ . Therefore, the wage rate for skilled workers in the post-trade liberalisation steady-state ( $W_S'$ ) will be lower than that in the initial (pre-trade liberalisation) steady-state ( $W_S$ ):  $W_S' < W_S$ . The wage rate for the unskilled workers in the post-trade liberalisation steady-state ( $W_L'$ ) will be higher than that in the initial (pre-trade liberalisation) steady-state ( $W_L$ ):  $W_L' > W_L$ . Thus, as a

consequence of trade liberalisation, the relative wage rate of unskilled labour increases

$[\frac{W_L'}{W_S'} = w' > w = \frac{W_L}{W_S}]$ , this will affect the returns to the investment in education.

**(i) The case of unskilled workers**

As in the case of the skill abundant country unskilled workers that have just finish the background schooling period and have  $T$  periods to go until the end of their working life are in a different situation from those that at time of trade liberalisation have already worked as unskilled.

The first type of individuals, observe trade liberalisation and decide their course of action considering post-trade prices and labour market conditions. Thus, as the critical level of ability is a positive function of the relative wage of unskilled workers [see Eq. 9a], fewer individuals in the beginning of their career will opt to become skilled than in previous generations. For all the individuals with a level of ability level in the interval  $[\tilde{\alpha}_{t=0}', 1]$  the returns on the investment in education are positive under post-trade as well pre-trade prices. They are losers of trade liberalisation since, by Eq. 13, their actual rate of return on the investment in education decrease and, by Eq. 23, their lifetime earnings will also be lower than in the absence of trade liberalisation.

The second type of individuals, observe trade liberalisation after having decided not to invest in education in the beginning of their career. As staying unskilled become more attractive, they will not have an incentive to change their course of action. They are winners of trade liberalisation. Their expected lifetime earnings increase as depicted in equation 38.

$$\int_t^T W_L' > \int_t^T W_L \tag{38}$$

**(ii) The case of students**

In the case of the unskilled labour abundant country, as a consequence of trade liberalisation, on one hand, due to lower discounted benefits and higher forgone earnings, the discounted value of net returns on education decrease. On the other hand,



due to lower tuition fees during the remaining schooling period it increases.

The actual discounted value of net returns of students  $[R(\alpha)'_{t < E}]$  given by Eq. 30], will differ from the expected value  $[R(\alpha)]$  given by Eq. 7]. For students, the difference between  $R(\alpha)$  and  $R(\alpha)'_{t < E}$  [given by Eq. 31] is always negative<sup>23</sup>. This means that as a consequence of trade liberalisation students have returns on education lower than expected. Moreover,  $R(\alpha)'_{t < E}$  is equal to zero for

$$\begin{aligned} \tilde{\alpha}'_{t < E} = & \frac{e^{r(E+T)}(e^{rt}-1)W_S + e^{rT}(e^{rE}-e^{rt})W_S'}{e^{rt}(e^{rT}-e^{rE})W_S'}\beta + \\ & + \frac{e^{r(E+T)}(e^{rt}-1)W_L + e^{rE}(e^{rT}-e^{rt})W_L'}{e^{rt}(e^{rT}-e^{rE})W_S'} \end{aligned} \quad (39)$$

Therefore, those with a level of ability in the interval  $]\tilde{\alpha}, \tilde{\alpha}'_{t < E}[$  will have negative returns on their investment in education.

Thus, all students have returns on the investment in education lower than expected. The most severe situation is those of students with a level of ability in the interval  $]\tilde{\alpha}, \tilde{\alpha}'_{t < E}[$  who have the additional psychological cost of knowing that had they decided to remain unskilled in the beginning of their working life, their lifetime earnings would have been higher.

Let's examine if they would be better off by dropping school and starting to work as unskilled. If the expected earnings working as unskilled surpass the expected earnings of remaining a student, the rational decision will be dropping school. The right and left hand side of Eq. 35, respectively, depict the lifetime earnings in each of these situations:

$$\begin{aligned} \int_E^T \alpha W_S' e^{-rz} dz - \int_t^E \beta W_S' e^{-rz} dz > \int_t^T W_L' e^{-rz} dz \\ \alpha > \frac{e^{rT}(e^{rE}-e^{rt})}{e^{rt}(e^{rT}-e^{rE})}\beta + \frac{e^{rE}(e^{rT}-e^{rt})}{e^{rt}(e^{rT}-e^{rE})}w' = \tilde{\alpha}^* \end{aligned} \quad (40)$$

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<sup>23</sup> Note that all students have  $\alpha > \tilde{\alpha}$  thus  $R(\alpha) > 0$ . Accordingly, if  $R(\alpha) - R(\alpha)'_{t < E} > 0$  for all  $\alpha > \tilde{\alpha}$ , it must be the case that  $R(\alpha)'_{t < E} < R(\alpha)$ .

Note that  $\tilde{\alpha} < \tilde{\alpha}^* < \tilde{\alpha}'_{t < E}$  thus, students with an ability level in the interval  $[\tilde{\alpha}, \tilde{\alpha}^*]$  will drop out of the education system losing the money already invested in education<sup>24</sup>. Students with an ability level in the interval  $[\tilde{\alpha}^*, \tilde{\alpha}'_{t < E}]$ , although regretting their previous decision, will stick to it, facing lifetime earnings below their potential level (they would have had higher earnings if at the beginning of their working life they decided to remain unskilled instead of becoming skilled). The remaining, students with an ability level in the interval  $[\tilde{\alpha}'_{t < E}, 1]$ , have positive returns on the investment in education but lower than expected when they committed their course of actions.

	Life-time earnings	LE'-LE
<b>In the absence of trade liberalisation (LE')</b>	$\int_E^T \alpha W_S e^{-rz} dz - \int_0^E \beta W_S e^{-rz} dz$	
<b>With trade liberalisation at <math>t</math> for those who drop formal education</b>	$-\int_0^t \beta W_S e^{-rz} dz + \int_t^T W_L' e^{-rz} dz$	$\int_t^E \beta W_S e^{-rz} dz + \int_t^T W_L' e^{-rz} dz - \int_E^T \alpha W_S dz$ equal to zero for $\alpha = \alpha^* + \frac{e^{rE}(e^{rT} - e^{rt})}{e^{rt}(e^{rT} - e^{rE})} w' \left( \frac{W_S'}{W_S} - 1 \right) < \alpha^*$ and $\alpha < \tilde{\alpha}$ for $t > \frac{\text{Log} \left[ \frac{e^{rT}(W_L' + W_S \beta)}{(e^{rT} - 1)W_L + W_L' + e^{rT}W_S \beta} \right]}{r}$
<b>With trade liberalisation at <math>t</math> for those who continue their formal education</b>	$-\left[ \int_0^t \beta W_S e^{-rz} dz + \int_t^E \beta W_S' e^{-rz} dz \right] + \int_E^T \alpha (W_S' - W_S) e^{-rz} dz + \int_t^E \beta (W_S - W_S') e^{-rz} dz$	equal to zero for $\alpha = \frac{e^{rE}(e^{rT} - e^{rt})}{e^{rt}(e^{rT} - e^{rE})} \beta < \alpha^*$

<sup>24</sup> Note that under this framework the education costs are sunk.

Under this setting we can conclude that the negative effects of trade differ among students of the same age but different levels of ability: the higher the level of ability the lower the losses.

Moreover there will also be differences in trade effects between younger and older generation. They lie in the number of individuals with the same age profile in each of the depicted situations. Eq. 36 and 37 show the relation between the ability cut offs and age:

$$\frac{\partial \tilde{\alpha}^*}{\partial t} = - \frac{e^{r(E+T)} r(W_L' + W_S' \beta)}{(e^{rT} - e^{rE}) W_S'} \quad (41)$$

$$\begin{aligned} \frac{\partial \tilde{\alpha}'_{t < E}}{\partial t} &= - \frac{e^{r(E+T)} r(W_L' + W_S' \beta)}{(e^{rT} - e^{rE}) W_S'} + \frac{e^{r(E+T)} r(W_L + W_S \beta)}{(e^{rT} - e^{rE}) W_S'} = \\ &= \frac{\partial \tilde{\alpha}^*}{\partial t} + \frac{e^{r(E+T)} r(W_L + W_S \beta)}{(e^{rT} - e^{rE}) W_S'} \end{aligned} \quad (42)$$

The number of people with an ability level in the interval  $\left] \tilde{\alpha}^*, \tilde{\alpha}'_{t < E} \right[$  is higher in older generations than in younger ones, specially if  $\beta > -\frac{\Delta W_L}{\Delta W_S}$  because in this situation an increase in age leads to a decrease in  $\tilde{\alpha}^*$  but an increase in  $\tilde{\alpha}'_{t < E}$ . Thus, not only in older generations there will be less people deciding to drop school but also less people facing post-liberalisation positive returns on their investment in education.

In addition, among those that have positive return on their investment in education and the same level of ability, the older they are the higher the loss of returns if  $\beta < -\frac{\Delta W_L}{\Delta W_S} = \frac{W_L' - W_L}{W_S - W_S'}$ . The converse is valid for  $\beta > -\frac{\Delta W_L}{\Delta W_S}$ .

### (ii) The case of skilled workers

The traditional analysis considers that this type of workers loses as a consequence of trade liberalisation due to lower wage rate. Here we argue that, by not considering the change in the returns on acquired education implied by trade liberalisation, they underestimate their losses. Moreover, we allow for changes in the labour status. Despite their qualifications, skilled workers can opt to work as unskilled.

This new features brings interesting additional insights.

As a consequence of trade liberalisation all skilled workers will face a disappointing rate of return on education. The discounted benefits of the investment in education become lower than expected. The actual rate of return to the investment in education is equal to  $r_E(\alpha)'$  [defined on Eq. 27a] which is lower than  $r_E(\alpha)$  [defined on Eq. 10]

Moreover, since all the individuals that expect a positive return from education decide to become skilled, some individuals will regret the decision made when younger. Particularly, this will be the case of those that face negative net returns to education. The actual net discounted benefits of the investment in education [ $R(\alpha)'$  defined on Eq. 25] will be lower than zero for  $\alpha < \tilde{\alpha}'$  [defined on Eq. 26]. However, all the individuals with a level of ability higher  $\tilde{\alpha}$  [defined on Eq. 8] decided to became skilled. As  $R(\alpha)'$  is negative for  $\alpha \in [\tilde{\alpha}, \tilde{\alpha}']$ <sup>25</sup>, the less able skilled workers will face capital losses in the form of negative returns on the investment in education.

However, they can reverse their previous decision and change occupation. Let's examine if the capital losses for these individuals are in such an amount that some of them may even prefer to work as unskilled in spite of having already invested in education. If the expected earnings working as unskilled surpass the expected earnings of remaining skilled, the rational decision will be to work as unskilled even after

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<sup>25</sup> Note that  $R(\alpha)' = R(\alpha) + \int_t^T [(W_L - W_L') - (W_S - W_S')\alpha] e^{-rz} dz$ . Moreover, in the unskilled labour abundant country,

$$\forall \alpha, \int_t^T [(W_L - W_L') - (W_S - W_S')\alpha] e^{-rz} dz = \frac{(e^{rT} - e^{rt})[(W_L - W_L') - (W_S - W_S')\alpha]}{e^{r(t+T)}r} < 0.$$

Accordingly,  $\forall \alpha, R(\alpha) > R(\alpha)'$ . For  $\alpha = \tilde{\alpha}$ ,  $R(\alpha) = 0$  and  $R(\alpha)' = \int_t^T [(W_L - W_L') - (W_S - W_S')\alpha] e^{-rz} dz < 0$ . For

$\tilde{\alpha} < \alpha < \tilde{\alpha}'$ ,  $R(\alpha) > 0$  and  $R(\alpha)' < 0$ . For  $\alpha = \tilde{\alpha}'$ ,  $R(\alpha) > 0$  and  $R(\alpha)' = 0$ .

Finally, for  $\alpha > \tilde{\alpha}'$ ,  $R(\alpha) > R(\alpha)' > 0$ .

having invested in education. The right and left hand side of Eq. 39, respectively, depict the lifetime earnings in each of these situations:

$$\int_t^T W_L' e^{-rz} dz > \int_t^T \alpha W_S' e^{-rz} dz \quad (43)$$

Thus, if the change in prices is high enough that we have  $\tilde{\alpha} < w' < \tilde{\alpha}'$ <sup>26</sup>, individuals with a level of ability in the interval  $]\tilde{\alpha}, w'[$ <sup>27</sup> will decide to work as unskilled. For them, the transition involves a change of occupation.

**Figure 3 – Skilled labour: Regrets versus Reversals**



Figure 3 illustrates these three possible situations for skilled workers in the unskilled labour abundant country. As a consequence of trade liberalisation, all the skilled workers face disappointing returns on their investment in education. Those with ability level in the segment A regret their decision of becoming skilled. A proportion of those decide to reverse it [segment B].

The dimension of each of the segments varies across generations.  $\tilde{\alpha}$  does not depend on age however,  $\tilde{\alpha}'$  does: is a negative function of age in the unskilled labour abundant country [for  $W_L' > W_L$  and  $W_S' < W_S$ , by Eq. 29  $\partial \tilde{\alpha}' / \partial t < 0$ ] Thus, for older generations segment A is lower than for younger generations. Accordingly, the proportion of the population (in absolute and relative terms) in each generation that faces negative returns on the investment in education (the more severe losses implied by trade) is higher in younger generations. In older generations, fewer skilled workers face negative returns on the investment in education and more face returns that, in spite of being positive, are lower than expected.

<sup>26</sup> Note that  $\tilde{\alpha}'$  is always higher than  $w'$  and  $\tilde{\alpha}$  is always higher than  $w$  but not necessarily higher than  $w'$  as in this country  $w' > w$ .

<sup>27</sup> Note that  $w' > \tilde{\alpha} \Leftrightarrow w' > \frac{1-e^{-rE}}{e^{-rS}-e^{-rT}} \beta + \frac{1-e^{-rT}}{e^{-rS}-e^{-rT}} * w$  which is possible.

Note that, as  $\tilde{\alpha}'$  is a negative function of age, in older generations we can have  $\tilde{\alpha} < \tilde{\alpha}' < w'$ . In this circumstance, although these workers do not regret the decision made when younger, they would be better off by changing occupation after trade liberalisation.

For all the skilled workers that decide to change occupation, the trade induced change on life-time earnings equals  $LE^1 - LE = \int_t^T (W_L^1 - \alpha W_S) e^{-rz} dz = (W_L^1 - \alpha W_S) \frac{e^{rT} - e^{rt}}{e^{r(T+t)} r}$ .

Trade induces losses to the more able of those that change their labour status (those with a level of ability higher than  $\frac{W_L^1}{W_S}$ ) and gains to the remaining. Across individuals with the same level of ability but different age profiles, younger individuals suffer higher losses. Conversely, among the winners, the younger have higher benefits.

For all the skilled workers that remain the same occupation, the losses in life-time earnings equals  $\alpha \int_t^T (W_S^1 - W_S) e^{rz} dz$ . As in the previous case, younger individuals suffer higher losses.

Moreover, if the level of ability lies in the interval  $]w', \tilde{\alpha}'[$ , younger individuals suffer higher capital losses on their investment in education<sup>28</sup>. If the level of ability lies in the interval  $]\tilde{\alpha}', 1[$ , younger individuals suffer higher negative differences between the expected and effective the rate of return on education<sup>29</sup>.

In the unskilled labour abundant country, the severity of the trade induced losses higher for younger generations.

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<sup>28</sup> Note that  $\frac{\partial[R(\alpha) - R(\alpha)']}{\partial t} = -\frac{\partial[R(\alpha)']}{\partial t} = -\frac{(W_L^1 - W_L) + (W_S - W_S')\alpha}{e^{rt}} < 0$

<sup>29</sup> Note that  $\frac{\partial[r_E - r_E']}{\partial t} = -\frac{\partial[r_E']}{\partial t} = -\frac{r[(W_L^1 - W_L) + (W_S - W_S')\alpha]}{e^{r(t-E)}(e^{rE} - 1)(W_L + W_S\beta)} < 0$

### 2.4.3.2. Factor Endowments in the New Steady-State

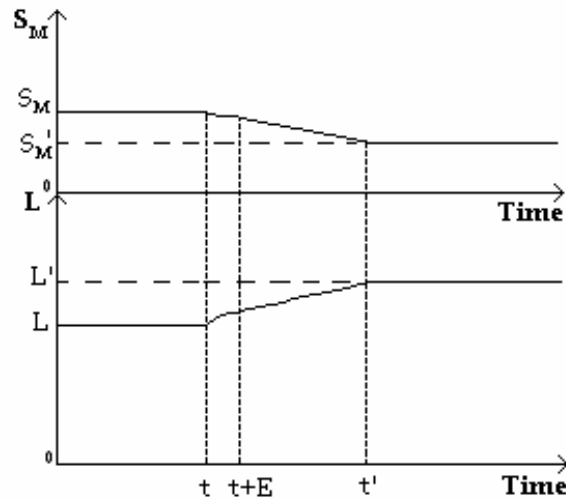
Under our framework, trade in the unskilled labour abundant country leads to an decrease in the return to education. As a consequence the equilibrium level of the critical level of ability decreases leading to an increase in the number of unskilled workers and to a narrowing in the number of skilled workers.

The new equilibrium supply of skilled and unskilled labour is given by Eq. 21 and Eq. 22 with  $\tilde{\alpha} = \tilde{\alpha}_{t=0}'$  where  $\tilde{\alpha}_{t=0}'$  is the new steady state ability cut-off. Thus, the changes in the supply of skilled and unskilled labour equal those in the skill abundant country but have opposite sign [see Eq. 33 and 34]. Additionally, in the presence of fewer students, less units of skill will be allocated to education and more to production.

### 2.4.3.3. Dynamics of Labour Supply

Figure 4 depicts the dynamics of unskilled and skilled labour supply for use in manufacturing between the two steady-states in the unskilled labour abundant country.

Figure 4 - Dynamics of labour supply in the unskilled labour abundant country



Immediately after trade liberalisation, the supply of unskilled workers increases for two reasons. First, as a consequence of trade liberalisation more individuals in the beginning of their working life choose to remain unskilled. Second, in the presence of occupation reversal, some skilled workers decide to change occupation and some students drop out of the education system. However, the immediate negative effect on  $S_M$  will be less pronounced for two reasons. First, with fewer students, less

educational services are needed and therefore more units of skill are available for use in manufacturing. Second, not all students with an ability level lower than the new steady state cut-off drop out of the education system.

Until  $t+E$ , the number of students continues to decrease - more students finish education than enter the educational system. The positive change in the supply of unskilled labour equals the sum of the negative change on the number of students and on the supply of skilled labour.

At  $t+E$  the number of students and skill units allocated to education will stabilise. However, considering the result that not all individuals with a level of ability lower than the new steady-state cut off  $[\tilde{\alpha}_{t=0}]$  will change occupation, the full adjustment the new equilibrium level of unskilled and skilled labour supply will take some time and be progressive. By assuming that each individual is replaced by an identical one in terms of ability upon death, the time transition will take equals  $T$  minus the age of the younger skilled worker that has a level of ability in the interval  $[w', \tilde{\alpha}_{t=0}]$ <sup>30</sup>. As for any  $t$ ,  $\tilde{\alpha}_{t=0} > w'$  the transition will take time  $T-E$ .

According to the theory on variable factor supplies and H-O-S model (e.g. Martin, 1976; Neary, 1978, Woodland, 1982), provided that factor supplies are not backward-bending and there is incomplete specialisation, there will be a shift to specialisation in the unskilled labour intensive good ( $X_1$ ) in the unskill abundant country as both the rise in  $L$  and the fall in  $S_M$  produce positive Rybczynski effects on  $X_1$  and negative effects on  $X_2$ . This result is consistent with the findings of Findlay and Kierzkowski (1983) and Borsook (1987). By modelling adjustment, we present new results. In particular, we find that this shift is progressive and the full effect of trade on specialisation will only occur at time  $t+(T-E)$ .

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<sup>30</sup> In the absence of occupation reversals, ie if  $w' < \tilde{\alpha}$ , the interval of the level of ability is not  $[w', \tilde{\alpha}]$  but  $[\tilde{\alpha}, \tilde{\alpha}]$ .



## APPENDIX 1

For unskilled workers with  $t \leq E$ , the actual discounted value of net returns of education (discounted for  $t=0$ ) accounting for trade liberalisation at  $t$  is equal to  $R(\alpha)'_{t \leq E}$  [defined in Eq. 30]. Solving for  $R(\alpha)'_{t \leq E} = 0$  we get the level of ability starting from which, accounting for trade liberalisation at  $t$ , investing in education at  $t=0$  would have had positive net returns<sup>31</sup>:

$$\begin{aligned} \tilde{\alpha}'_{t < E} = & \frac{e^{r(T+E)}(e^{rt} - 1)W_S + e^{rT}(e^{rE} - e^{rt})W_S'}{e^{rt}(e^{rT} - e^{rE})W_S'} \beta + \\ & + \frac{e^{r(T+E)}(e^{rt} - 1)W_L + e^{rE}(e^{rT} - e^{rt})W_L'}{e^{rt}(e^{rT} - e^{rE})W_S'} \end{aligned} \quad (24)$$

In this situations, unskilled workers, aged at the time of trade liberalisation  $t < E$ , with a level of ability in the interval  $[\tilde{\alpha}'_{t < E}, \tilde{\alpha}]$  have lower working earnings than those they could have had given their ability level. They regret their decision of not having become skilled in the beginning of their working lives.

Note that if trade liberalisation at  $t$  had been anticipated at  $t=0$ , the rational decision for these workers would have been investing in education immediately. Postponing the investment would have meant lower discounted net returns.

However, if trade liberalisation (at  $t < E$ ) had been anticipated only at  $t_0$ , with  $0 < t_0 < t$ , just those with  $R(\alpha, t_0)'_{t < E} > 0$  have working earnings below their possibilities.

$$\begin{aligned} R(\alpha, t_0)'_{t < E} = & \int_{t_0+E}^T (\alpha W_S' - W_L') e^{-r(z-t_0)} dz - \\ & - \left[ \int_{t_0}^{t_0+t} (\beta W_S + W_L) e^{-r(z-t_0)} dz + \int_t^{t+E} (\beta W_S' + W_L') e^{-r(z-t_0)} dz \right] \end{aligned}$$

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<sup>31</sup> Note that for  $t=E$ ,  $\tilde{\alpha}'_{t=E} = \frac{e^{rT}(e^{rt} - 1)(W_S \beta + W_L) + (e^{rT} - e^{rt})W_L'}{(e^{rT} - e^{rt})W_S'}$ .

As  $R(\alpha, t_0)'_{t < E}$  is lower than  $R(\alpha)'_{t < E}$ , the associated critical level of ability is higher. Thus, as a consequence of trade liberalisation, fewer unskilled workers aged  $t < E$  would regret their previous decision.

## APPENDIX 2

$$\tilde{\alpha}(t)' < \tilde{\alpha} \text{ for } \alpha > \tilde{\alpha}(t)' \text{ and } t < T + \frac{1}{r} \ln \left[ \frac{W_L - W_L'}{\alpha W_S' - W_L'} \left( \frac{e^{rT} - 1}{e^{rT}} \right) + \frac{W_S' - W_S}{\alpha W_S' - W_L'} \left( \frac{e^{rT} - e^{rE}}{e^{r(E+T)}} \alpha - \frac{e^{rE} - 1}{e^{rE}} \beta \right) + \frac{1}{e^{rT}} \right]$$

*Proof:*

We know that  $R(\alpha, t)' > R(\alpha) \Rightarrow \tilde{\alpha}(t)' < \tilde{\alpha}$ . We are going to prove that  $R(\alpha, t)' > R(\alpha)$  until certain age limit.

$$R(\alpha, t)' = \int_{t+E}^T (\alpha W_S' - W_L') e^{-r(z-t)} dz - \int_t^{t+E} (\beta W_S' + W_L') e^{-r(z-t)} dz$$

$$R(\alpha) = \int_E^T (\alpha W_S - W_L) e^{-rz} dz - \int_0^E (\beta W_S + W_L) e^{-rz} dz$$

$$\begin{aligned}
R(\alpha, t)' > R(\alpha) &\Leftrightarrow \\
&\Leftrightarrow (\alpha W_S' - W_L') \frac{e^{-rE} - e^{-r(T-t)}}{r} - (\beta W_S' + W_L') \frac{1 - e^{-rE}}{r} > \\
&> (\alpha W_S - W_L) \frac{e^{-rE} - e^{-rT}}{r} - (\beta W_S + W_L) \frac{1 - e^{-rE}}{r} \Leftrightarrow \\
&\Leftrightarrow e^{-r(T-t)} (\alpha W_S' - W_L') < \\
&\quad [(W_L - W_L') - (W_S - W_S') \alpha] (e^{-rE} - e^{-rT}) + \\
&\quad + [(W_L - W_L') + (W_S - W_S') \beta] (1 - e^{-rE}) + (\alpha W_S' - W_L') e^{-rT} \Leftrightarrow \\
&\Leftrightarrow e^{-r(T-t)} < Z \text{ with} \\
Z &= \frac{[(W_L - W_L') + (W_S' - W_S) \alpha] (e^{-rE} - e^{-rT}) + [(W_L - W_L') + (W_S - W_S') \beta] (1 - e^{-rE}) + (\alpha W_S' - W_L') e^{-rT}}{(\alpha W_S' - W_L')} \\
&\Leftrightarrow t < T + \frac{1}{r} \ln(Z) \Leftrightarrow \\
&\Leftrightarrow t < T + \frac{1}{r} \ln(Z)
\end{aligned}$$

Condition :  $Z > 0$

proof that it is always the case for  $\alpha > \tilde{\alpha}(t)'$

$$\begin{aligned}
Z &= \frac{[(W_L - W_L') + (W_S' - W_S) \alpha] (e^{-rE} - e^{-rT}) + [(W_L - W_L') + (W_S - W_S') \beta] (1 - e^{-rE}) + (\alpha W_S' - W_L') e^{-rT}}{(\alpha W_S' - W_L')} = \\
&= \frac{W_L - W_L'}{\alpha W_S' - W_L'} \left( \frac{e^{rT} - 1}{e^{rT}} \right) + \frac{1}{e^{rT}} + \frac{W_S' - W_S}{\alpha W_S' - W_L'} \left( \frac{e^{rT} - e^{rE}}{e^{r(E+T)}} \alpha - \frac{e^{rE} - 1}{e^{rE}} \beta \right)
\end{aligned}$$

As

$$W_L' < W_L \Leftrightarrow W_L - W_L' > 0$$

$$\left( \frac{e^{rT} - 1}{e^{rT}} \right) > 0, \frac{1}{e^{rT}} > 0$$

$$\text{For } \alpha > \tilde{\alpha}(t)', \alpha W_S' - W_L' > 0$$

$$\text{Thus, for } \alpha > \tilde{\alpha}(t)', \frac{W_L - W_L'}{\alpha W_S' - W_L'} \left( \frac{e^{rT} - 1}{e^{rT}} \right) + \frac{1}{e^{rT}} > 0$$

$$W_S' > W_S \Leftrightarrow W_S' - W_S > 0$$

$$\frac{e^{rT} - e^{rE}}{e^{r(E+T)}} \alpha > \frac{e^{rE} - 1}{e^{rE}} \beta \Leftrightarrow \alpha > \Gamma \beta \text{ which is always the case when } \alpha > \tilde{\alpha}(t)' = \Lambda \beta + (1 + \Lambda)w \text{ with } \Lambda > \Gamma > 0$$

## APPENDIX 3

In the skill abundant country  $R(\alpha)_{t < E} > R(\alpha)$  for all students

*Proof*

With  $W_L > W_L'$  and  $W_S < W_S'$  both  $\int_t^T (W_L - W_L') e^{-rz} dz$  and  $(W_S' - W_S)$  are

positive. Moreover, all students have  $\alpha > \tilde{\alpha} = \frac{e^{rT}(e^{rE} - 1)}{e^{rT} - e^{rE}} \beta + \frac{e^{rE}(e^{rT} - 1)}{e^{rT} - e^{rE}} \frac{W_L}{W_S}$ . As

$\frac{e^{rE}(e^{rT} - 1)}{e^{rT} - e^{rE}} \frac{W_L}{W_S} > 0$ , if  $\alpha > \frac{e^{rT}(e^{rE} - 1)}{e^{rT} - e^{rE}} \beta + \frac{e^{rE}(e^{rT} - 1)}{e^{rT} - e^{rE}} \frac{W_L}{W_S}$  then  $\alpha > \frac{e^{rT}(e^{rE} - 1)}{e^{rT} - e^{rE}} \beta$ .

Multiplying both sides of the inequation by  $(e^{rT} - e^{rE})e^{rt} > 0$  we get:

$\alpha(e^{rT} - e^{rE})e^{rt} > \frac{e^{rT}(e^{rE} - 1)}{e^{rT} - e^{rE}}(e^{rT} - e^{rE})e^{rt} \beta \Leftrightarrow \alpha(e^{rT} - e^{rE})e^{rt} > e^{r(T+t)}(e^{rE} - 1)\beta$ . As

$e^{r(T+t)}(e^{rE} - 1)\beta > e^{rT}(e^{rE} - e^t)\beta$  then we can affirm that for all the students

$$\int_E^T \alpha e^{-rz} dz - \int_t^E \beta e^{-rz} dz = \frac{\alpha(e^{rT} - e^{rE})e^{rt} - \beta(e^{rE} - e^{rt})e^{rT}}{e^{r(T+t+E)r}} > 0.$$

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