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Trade Liberalisation and Human Capital Adjustment

by

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Abstract

This paper highlights the way in which workers of different age and ability are affected by anticipated and unanticipated trade liberalisations. A two-factor (skilled and unskilled labour), two-sector Heckscher-Ohlin model is supplemented with an education sector which uses skilled labour and time to convert unskilled into skilled workers. A skilled worker's income depends on ability, but all unskilled workers have the same income. Trade liberalisation in an abundant country increases the relative wage and induces skill upgrading by existing workforce. Younger and more able workers are most likely to upgrade, but not all are better off after liberalisation: Older and less able upgraders are likely to lose. For an anticipated liberalisation the preferred upgrading strategies depend on ability and much of the upgrading takes place before liberalisation. This implies that some workers who would have upgraded had they anticipated the liberalisation will not do so if it is unanticipated, and post-liberalisation adjustment assistance will fail to compensate some losers and distort the upgrading decisions of others.

Outline

Non-Technical Summary

The social impact of globalisation, and in particular its labour market consequences, are controversial. Fears that this process of increased integration into world markets implies increasing job losses and downward pressure on wages are widespread, often resulting in demands for protection. Growing concerns about the importance of such adjustment costs in the policy community are evident. In the European Union, a Special Eurobarometer on the 'Future of Europe' undertaken by the European Commission (2006) indicates that a (relative) majority of Europeans (47% of interviewees) consider first and foremost that globalisation is a threat to employment and companies in their country (compared with 37% who see it as a good opportunity for companies in their country). Perhaps more important, a comparison of these results with those from a similar survey carried out in 2003 indicates that negative perceptions towards globalisation have risen sharply in most of the older member-states. Concerns about this issue are also evident in the US political discourse.

Adjustment to trade liberalisation involves more than the involuntary relocation of workers among jobs of the same or similar skill levels. In the context of the HOS model, the product price changes that follow from trade liberalisation induce changes in skill premia. Accepting that trade liberalisation in developed countries leads to an increase in the relative return to skilled labour, skill upgrading by the existing workforce will be an important part of the adjustment process, and whether a worker chooses to upgrade or not will depend on that worker's age and ability. Like all human capital accumulation, skill upgrading can be time consuming thus extending the adjustment process well beyond the short term. Moreover, understanding the implications of freer trade for skill acquisition is important given the theoretical possibility of poverty traps generated by lack of education and occupational choice, and the role of human capital accumulation in growth.

This paper aims to contribute to a better understanding of the impact of increased globalisation on labour market adjustment by examining the role of human capital formation in this process. It focuses on adjustment by the existing workforce, analysing how worker characteristics, such as age, experience, skills and ability, shape labour market outcomes in an open economy context. Results indicate that trade liberalisation in a relatively skilled labour abundant country increases the relative skilled wage and induces skill upgrading by the existing workforce. The younger and more able unskilled workers are most likely to upgrade. But not all upgraders are better off as a result of the liberalisation. Older and less able upgraders are likely to lose. For an anticipated liberalisation we show that the preferred upgrading strategies depend on a worker's ability and that much of the upgrading will take place before liberalisation. This implies that some workers who would have upgraded had they anticipated the liberalisation will not if it is unanticipated, and that adjustment assistance that applies only to post-liberalisation upgraders will fail to compensate some losers and distort the upgrading decisions of others.

1. Introduction

The links between product prices and factor returns are a key element of general equilibrium trade models. Interest in these links was heightened by the recent "trade and wages" debate, where lower prices of unskilled labour intensive products were put forward as one explanation for the decline in the relative wage of unskilled workers in advanced, skill-abundant countries. The underlying argument was based on the Stopler-Samuelson theorem which implies that trade liberalisation in unskilled labour scarce countries will lead to a fall in the relative price of unskilled labour intensive imports and thence a fall in the relative return to unskilled labour. The general conclusion of this debate seems to be that, while trade liberalisation may have been a contributing factor, technological change played the major role.

The changes in relative product prices that follow from trade liberalisation will also cause domestic resource reallocation towards those traded goods industries in which the country has a comparative advantage. These reallocations are an important source of the long run gains from trade. But in the short run they will involve adjustment costs, since resources cannot shift frictionlessly among activities. Adjusting workers in particular are likely to suffer periods of unemployment in the short-run, in addition to any longer run changes in their income streams. Although adjustment costs borne by workers are conventionally viewed as transitory and small relative to the benefits of trade liberalisation[1], more recent work indicates that they may be larger than previously thought (see, for example, Trefler (2004)) and they are of concern for policy makers, not least because they represent the focal point of resistance to trade reform[2].

Our aim in this paper is to extend the analysis of adjustment to trade liberalisation in a slightly different direction. Accepting that trade liberalisation in developed countries leads to an increase in the relative return to skilled labour, we explore the implications that this has for *skill acquisition* by the existing workforce - i.e. not just by new entrants. This is a relatively neglected aspect of adjustment. By treating workers within each skill group as

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[1] This, for example, is the conclusion reached by Matusz and Tarr (2002) in a recent survey of evidence.
[2] The issues raised by short run adjustment costs have received some attention in the literature. See Davidson and Matusz (2004)

homogeneous, most trade models implicitly assume all skilled and unskilled workers are affected equally. But the changes in relative factor returns will cause some currently unskilled workers to rethink and reverse their decision to stay unskilled. The adjustment process that this induces begins immediately, and may not be completed until long after the short run frictions have been overcome. Worker characteristics, particularly age and ability, will be crucial in determining their decisions, and our paper highlights the way in which workers of different age and ability are affected by a trade expansion.

Our model modifies and extends earlier work by Findlay and Kierzkowski (1983) [FK] and Borsook (1986). We consider a small economy which consists of a manufacturing (traded goods) and an educational sector. The manufacturing sector is Heckscher Ohlin in structure and produces two traded goods using the services of skilled and unskilled labour. Unskilled workers enter the labour force without training. Education transforms unskilled individuals into skilled workers but takes time and resources[3]. We assume individuals differ in their (exogenous) ability level and, while the income of the unskilled is independent of their ability, more able skilled workers earn a proportionately higher income. Following Becker (1993), we model the educational investment decision accounting for the relationship between earning profiles, ability and age. In contrast to previous models we allow individuals to change labour status at any time in their working lives. The decision to enter the labour market as unskilled can be reversed later through schooling. The return to education is an increasing function of ability and youth. Given relative product prices, all individuals with ability above an endogenous threshold will become skilled. A trade

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[3] FK and Borsook assume the economy is endowed with a fixed stock of educational capital. In the FK model all individuals are ex ante identical, and the productivity of those that choose to become skilled is positively related to the capital/student ratio at the time they are educated. But in a steady state all skilled workers are identical. Borsook assumes, as we do, an exogenous distribution of individual ability. His main concern is the link between ability and the amount of schooling undertaken by individuals of different ability. While the length of the time spent in school is fixed, more able students receive a more intensive education, because the optimal capital/student ratio is increasing in ability. Earnings differentials then reflect the interaction of ability and schooling and not just schooling alone. In both of these models the relative stock of educational capital is an important determinant of the pattern of trade. We simplify the educational process by assuming that skilled labour (staff) rather than some exogenously given educational capital is the educational input (besides students) and there is a fixed staff/student ratio. Since our educational process has the same length and skilled labour input for all students, regardless of ability, we assume that their productivity as skilled workers depends only on their inherent ability. Dinopoulos and Segerstrom (1999) make a similar assumption, but in their case schooling takes time only. In our case the trade pattern will be determined by inter-country differences in the length of working lives, birth rates and the efficiency of the educational sector.

liberalisation changes this steady state threshold and affects relative factor supplies and hence outputs in the long run. While we also consider these long run changes, which are the main focus of FK and Borsook, our main concern is with the medium run effects on the skill composition of the workforce existing at the time the liberalisation occurs or is announced.

Two key simplifying assumptions are worth reiterating upfront. First, we abstract completely from the short run frictional costs that are the focus of much of the adjustment literature. The movement of skilled and unskilled workers between production activities is assumed to be instantaneous and costless. This simplification allows us to highlight the adjustment through skill upgrading by the existing workforce that has been largely neglected to date. Second, the HO structure implies that, as long as a country's manufacturing sector is non-specialised, factor returns depend only on product prices. In particular factor returns are constant throughout the adjustment process, so that workers' skill upgrading decisions are based on fixed and known future earnings. It should be emphasised that these assumptions are made for simplification only. Their relaxation will greatly complicate the analysis but should not invalidate the general results.

We are concerned with issues in three areas. Section 3 considers the effects of an *unanticipated* trade liberalisation in a relatively skill abundant country. The increase in the relative return to skilled labour leads to some skill upgrading by the existing workforce. Which workers will choose to do so? Further, which of these workers will gain from skill upgrading (relative to the pre-liberalisation equilibrium)? In each ability cohort we determine an upgrader age cutoff, with younger workers upgrading and older workers remaining unskilled. The higher the ability level, the higher this age cutoff. But not all upgraders gain from the liberalisation, and for each ability cohort we can also determine an analogous gainer age cutoff, which is lower than the corresponding upgrader cutoff. Thus in any given ability cohort older upgraders tend to lose and younger upgraders to gain from the liberalisation. These results confirm the common perception that older adjusters lose.

The effects of an *announced* liberalisation (to take place at a known future date) are then derived in Section 4. Here our main concern is the pattern of upgrading in the workforce

existing at the time of the announcement. Which workers will choose to upgrade and when? Interestingly, we find that for those who decide to upgrade, the optimal timing of the upgrading depends only on ability. Upgraders fall into three ability categories. The highest ability upgraders will do so immediately after the announcement. The next highest group will upgrade immediately before the liberalisation and the final group immediately after. The significance of this is that much of the medium term adjustment (upgrading) to an announced liberalisation by the existing workforce will occur *before* the liberalisation takes place. Freund and McLaren (1999) provide evidence that trade flows begin to adjust before preferential trading arrangements come into force, and refer to models where firms make anticipatory "investments" to explain this. We show that anticipatory investments in human capital may be part of the same process.

The differences in the patterns of upgrading between anticipated and unanticipated liberalisations reveal that all workers (weakly) prefer that the liberalisation is announced. This feature is further exploited in Section 5 to compare patterns of upgrading under unanticipated and fully anticipated liberalisations. Specifically we can identify which workers, when faced with an unanticipated liberalisation, would claim "if I had known that was going to happen I would have acted differently". While such "regrets" are not an adjustment cost, they will partly condition an individual's attitudes to the liberalisation. Again it is older and less able workers that are most likely to regret their decision to remain unskilled without finding it worthwhile to reverse it. The more able workers, who still upgrade, will also regret not having done so earlier.

Section 6 briefly highlights two implications of our analysis for the design of programs of adjustment assistance. The first is to note that those undertaking adjustment (the upgraders) are a mixture of gainers and losers from the liberalisation. Any given age cohort contains both, depending on the upgrader's ability. Since the latter is likely to be unobservable, it will be difficult to target the assistance at losers. The second implication is that if the liberalisation is anticipated much of the upgrading will (and should) take place before it occurs. But if assistance is only provided post-liberalisation then early upgraders will not be covered. More importantly the decision on when to upgrade will be distorted towards the

post-liberalisation period. The next section sets out the model and determines the long run equilibrium supplies of skilled and unskilled labour.

2. The Model

2.1 Technology and factor prices

Consider an economy with a manufacturing sector producing two tradable goods (1 and 2), using two factors (unskilled labour (L) and skilled labour (S in efficiency units)) under standard constant returns to scale technologies. Factor services are assumed to be homogeneous and costlessly mobile between industries, implying that factor returns per efficiency unit (W_L and W_S) are common across industries. With perfectly competitive markets for goods and factors and assuming incomplete specialization, in the manufacturing sector in equilibrium the competitive profit conditions imply that

$$P_j = a_{Lj}W_L + a_{Sj}W_S \tag{1}$$

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. Relative product prices determine factor returns, given the manufacturing technology.

Skilled labour is also employed in the education sector, which turns unskilled into skilled workers, a process that takes E time periods and requires the services of β units of skilled labour per student. The quantity of skilled labour services available for use in manufacturing (S_M) then depends on the quantity of skilled labour services allocated to education (S_E). If X_E is the number of students, then the amount of skilled labour allocated to education is βX_E. Assuming full employment:

$$L = L_1 + L_2 = a_{L1} X_1 + a_{L2}X_2 \tag{2A}$$

$$S = S_M + S_E = (S_1 + S_2) + S_E = (a_{S1} X_1 + a_{S2}X_2) + \beta X_E \tag{2B}$$

where X_j denotes the output of good j. Finally, assume that at any common factor prices,

$$\frac{S_2}{L_2} > \frac{S_1}{L_1} \tag{3}$$

that is, there are no factor intensity reversals, with good 2 always being skill intensive.

2.2 Individual investment behaviour and human capital acquisition

We assume individuals are heterogeneous with respect to their ability, which is a combination of ordinary and general knowledge that is innate and acquired prior to working age[4]. Individuals are indexed by their ability (α) which for convenience we assume to be uniformly distributed among the population and to vary along the unit interval: $\alpha \in [0,1]$. Each individual's working lifetime is finite and exogenously given by T. We suppose that the gross working earnings, per unit of time, of an unskilled worker do not depend on ability and are equal to W_L. The gross working earnings of a skilled worker depend on the number of efficiency units of skill she possesses and are equal to αW_S[5]. Because skilled workers differ in ability they also differ in earnings. Moreover, the lifetime net earnings of skilled workers differ from their lifetime gross earnings, because of the cost of schooling.

Becoming skilled involves an investment in formal education, an investment which we assume can be undertaken at any time during an individual's working life. Consider an unskilled worker with t periods experience in the labour market (i.e. whose time to retirement is T-t periods). The net present value to this worker of now becoming skilled is the difference between discounted costs and discounted benefits:

$$R(\alpha,t) = -\int_0^E [\beta W_S + W_L]e^{-rz}dz + \int_E^{T-t} [\alpha W_S - W_L]e^{-rz}dz \qquad (4)$$

where r is the interest rate in a perfect capital market[6]. The first term on the right of (4) represents the cost of skill upgrading, and is composed of the direct cost (βW_S per period) and the opportunity cost (W_L). The second term is the present value of the wage premia earned by a skilled worker, and is the difference between her earnings as a skilled worker (which depend on her ability) and as an unskilled worker (which are independent of ability. The higher is $R(\alpha,t)$, the better the investment, and we assume all individuals with positive net returns to schooling will upgrade. Taking derivatives we see that, given a wage structure,

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[4] We can interpret this background period as the compulsory stages of education, for example.
[5] These assumptions are based on the idea that unskilled work involves standard tasks, while skilled work involves more complex tasks for which training is required and on which the time taken depends on the worker's ability.
[6] Clearly no worker for whom $T - t \leq E$ can benefit from skill upgrading.

$$\frac{\partial}{\partial t}R(\alpha,t) = -\frac{[\alpha W_S - W_L]}{e^{r[T-t]}} < 0 \quad \text{and} \quad \frac{\partial}{\partial \alpha}R(\alpha,t) = \frac{W_S}{r}[e^{-rE} - e^{-r[T-t]}] > 0 \qquad (5)$$

an individual of given ability with a positive return from education should undertake education as early as possible – i.e. before entering the workforce ($R(\alpha,0) > R(\alpha,t)$ for $t >$ 0). Equation (5) also indicates that the gains from becoming skilled increase with ability. We can solve $R(\tilde{\alpha},t) = 0$ to find the level of ability ($\tilde{\alpha}(t)$) above which an individual of age t would choose to skill upgrade:

$$\tilde{\alpha}(t) = \Gamma(t)\beta + [1 + \Gamma(t)]w = w + \Gamma(t)[\beta + w] \qquad (6)$$

with $\Gamma(t) \equiv \dfrac{e^{rT}[e^{rE} - 1]}{e^{rT} - e^{r[E+t]}}$ and $w = \dfrac{W_L}{W_S}$. In the steady state, all individuals with $\alpha > \tilde{\alpha}$ ($\equiv \tilde{\alpha}(0)$) will become skilled and individuals with $\alpha \leq \tilde{\alpha}$ will enter the labour market immediately unskilled. As $\Gamma(0) > 0$, $\beta > 0$ and $w > 0$, the critical level of ability ($\tilde{\alpha}$) is always higher than zero[7].
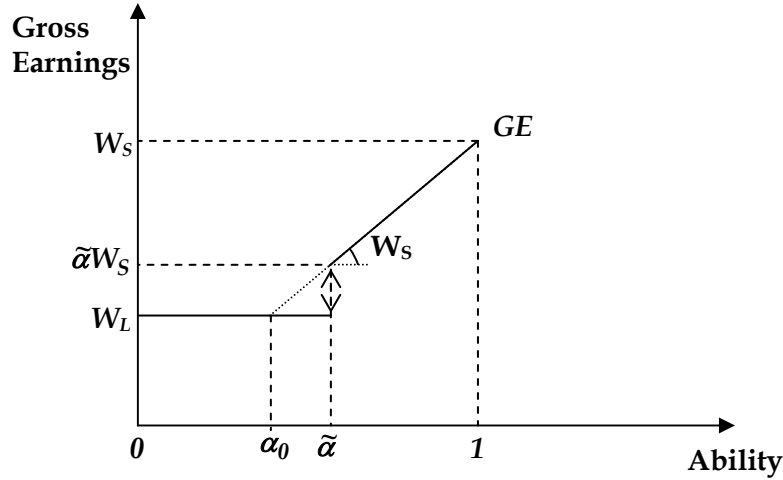
Figure 1 – Ability and Gross Earnings

Figure 1 illustrates the relationship between ability level and gross earnings (*GE*). In equilibrium, individuals with ability in the interval $[0, \tilde{\alpha}]$ do not 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

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[7] Note that if becoming skilled was instantaneous ($E = 0$), $\tilde{\alpha}$ would simply equal the relative wage (as then $\Gamma(0) = 0$).

ability become skilled and spend their post-educational work life earning αW_S per period. Gross earnings of skilled workers depend positively on ability, and vary along the interval $[\tilde{\alpha} W_S, W_S]$, with positive slope α. If education were costless, GE would be continuous, and individuals with ability in the interval $[\alpha_0, \tilde{\alpha}]$ would decide to become skilled. But costly education (in either time or resources) implies a decrease in the number of skilled workers and an increase in the average level of ability of the skilled labour force. In the steady state equilibrium those unskilled workers in the range $(\alpha_0, \tilde{\alpha}]$ have a positive skill premium (i.e. $\alpha W_S > W_L$), but the present value of this is not sufficient to offset the costs of education. The existence of this group will prove significant when we consider the adjustment process to an anticipated liberalisation below.

2.3. Factor endowments in the steady-state

We assume that at each point in time an exogenous number of individuals (n) are born and die. Thus the workforce at any time is equal to $Tn = N$. Furthermore, we assume each individual's replacement is identical in terms of ability. Thus, in the steady state $\tilde{\alpha} N$ individuals constitute the supply of unskilled labour. The remaining $[1-\tilde{\alpha}]N$ are either skilled ($[1-\tilde{\alpha}][T-E]n = [1-\tilde{\alpha}][1-\frac{E}{T}]N$) or students ($[1-\tilde{\alpha}]En = [1-\tilde{\alpha}]\frac{E}{T}N$). The average level of ability of individuals that decide to become skilled is $[1+\tilde{\alpha}]/2$. The supplies of unskilled and skilled labour services are then, respectively:

$$L = \tilde{\alpha} N \tag{7A}$$

$$S = \frac{1}{2}[1+\tilde{\alpha}][1-\tilde{\alpha}][1-\frac{E}{T}]N = \frac{1}{2}[1-\tilde{\alpha}^2][1-\frac{E}{T}]N \tag{7B}$$

Not all skilled labour services will be used in the production of goods, since β units of skilled labour are allocated to each student. The number of units of skill allocated to education and those available for goods production are then given by

$$S_E = \beta[1-\tilde{\alpha}]\frac{E}{T}N \tag{7C}$$

$$S_M = S - S_E = [1 - \tilde{\alpha}] \left[\frac{[1+\tilde{\alpha}]}{2} [1 - \frac{E}{T}] - \beta \frac{E}{T} \right] N \qquad (7D)^8$$

3. An Unanticipated Trade Liberalisation

In this section we compare the effects of an unanticipated trade liberalisation on factor returns and skill acquisition in a small skilled-labour abundant country[9]. Since world prices are given, the liberalisation changes domestic product and therefore domestic factor prices in accordance with the Stolper-Samuelson theorem. The real return to the abundant factor (skilled labour) will rise (from W_S to W_S'), and the real return to unskilled labour will fall (from W_L to W_L'), so that $w' < w$. We suppose the liberalisation occurs at time 0.

3.1 Skilled workers.

Consider a skilled worker with $T - t$ periods to retirement. The change in this worker's discounted future income is given by

$$G_S(\alpha, t) = \int_0^{T-t} \alpha [W_S' - W_S] e^{-rz} dz = \alpha \frac{[W_S' - W_S]}{r} \left\{ \frac{e^{rT} - e^{rt}}{e^{rT}} \right\} > 0 \qquad (8A)$$

All existing skilled workers gain from the liberalisation, but the gains are larger for younger and for more able workers [10].

3.2 Students

The gain to an erstwhile skilled worker still in the student phase ($t \le E$) is

$$G_E(\alpha, t) = - \int_0^{E-t} \beta [W_S' - W_S] e^{-rz} dz + \int_{E-t}^{T-t} \alpha [W_S' - W_S] e^{-rz} dz$$

$$= \frac{G_S(\alpha, E)}{e^{r[E-t]}} - \beta \frac{[W_S' - W_S]}{r} \left[\frac{e^{r[E-t]} - 1}{e^{r[E-t]}} \right] \qquad (8B)$$

Students benefit from an increase in their discounted earnings as skilled workers, but lose through an increase in the direct cost of education. They are net gainers overall, however[11].

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[8] The lifetime supply of skilled labour (in efficiency units) of the average skilled worker is $[1+\tilde{\alpha}][T-E]/2$. The number of units of skilled labour required to educate a skilled worker is βE. Therefore, when converted to an annual flow, the net supply of skilled labour of the average skilled worker over her working life is $\frac{[1+\tilde{\alpha}]}{2} [1 - \frac{E}{T}] - \beta \frac{E}{T}$.

[9] The outcomes for an unskilled labour abundant country follow analogously and are omitted for brevity.

[10] This income gain can alternatively be viewed as a (human) capital gain or a higher than expected return on education.

The biggest gainers at each ability level are the students on the verge of graduating at the time of liberalisation ($t = E$).

3.3 Unskilled workers

The equivalent comparison for continuing unskilled workers is given by

$$G_L(t) = \int_0^{T-t} [W_L' - W_L] e^{-rz} dz = -\frac{[W_L - W_L']}{r} \left\{ \frac{e^{rT} - e^{rt}}{e^{rT}} \right\} < 0 \qquad (8C)$$

All such workers lose, and the losses are larger for the younger workers. It is customary to then conclude that all unskilled workers lose as a consequence of liberalisation due to their lower wage. But this does not allow for reversal of the decision to stay unskilled, and skill upgrading will be an attractive alternative for some existing unskilled workers as we now show. Workers differ in age and ability, and it is informative to consider both dimensions.

We begin by considering workers of the same age but different abilities. The new ability cutoff for workers of age t is obtained by rewriting (6) at the new factor prices

$$\tilde{\alpha}'(t) = w' + \Gamma(t)[w' + \beta] \qquad (9)$$

All unskilled workers with ability in the range $\tilde{\alpha} - \tilde{\alpha}'(t)$ will find that skill upgrading raises their discounted lifetime earnings at the post-liberalisation factor prices. Using (6) we see that

$$\tilde{\alpha} - \tilde{\alpha}'(t) = [w - w'] + \Gamma(0)[w + \beta] - \Gamma(t)[w' + \beta]$$

which is positive for $t = 0$ (i.e. there are always gainers among the new entrants), but declining as t increases and becoming zero once t is sufficiently large[12]. Not all of those

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[11] Clearly the discounted value of their earnings must have exceeded the discounted direct cost of education at the pre-liberalisation skilled wage, otherwise education would not have been profitable in the first place. The liberalisation has simply increased both earnings and direct education costs in the same proportion.

[12] $\Gamma(t) = \frac{e^{rT}[e^{rE} - 1]}{[e^{rT} - e^{r[E+t]}]}$ is increasing in t and becomes increasingly large as t approaches $T - E$.

who upgrade "gain" from the liberalisation of course[13]. The gain for the upgraders is given by

$$G_U(\alpha,t) = \int_E^{T-t} [\alpha W_S' - W_L] e^{-rz} dz - \int_0^E [\beta W_S' + W_L] e^{-rz} dz \qquad (10)$$

By setting $G_U(\alpha,t) = 0$ we can solve for an ability cutoff at each age level ($\hat{\alpha}(t)$) above which upgrading workers are in fact better off as a result of the liberalisation, obtaining

$$\hat{\alpha}(t) = \Gamma(t)\beta + [1+\Gamma(t)]\frac{W_L}{W_S'}$$

It is then straightforward to show that

$$\hat{\alpha}(t) - \tilde{\alpha}'(t) = \frac{W_L - W_L'}{W_S'}\Gamma(t) > 0$$

Upgraders in the ability range $\hat{\alpha}(t) - \tilde{\alpha}'(t)$ are better off than they would have been had they remained unskilled, but are worse off than if the liberalisation had not occurred. Since $\Gamma(t)$ is increasing in t, this range is larger among older workers.

We can do similar calculations of age specific cutoffs for given ability levels. The return to upgrading for a worker of ability α and age t at the time of the liberalisation (time 0) is given by rewriting (4) at the new factor prices as $R(\alpha,t;0)$. Setting this term to zero, we can solve for the oldest worker of ability level α who finds skill upgrading worthwhile:

$$t(\alpha) = T - E + \frac{1}{r}\ln[1-\Delta(\alpha)] \qquad (11)$$

where
$$\Delta(\alpha) \equiv \frac{[e^{rE}-1][\beta W_S' + W_L']}{\alpha W_S' - W_L'} = \frac{\tilde{\alpha}' W_S' - W_L'}{\alpha W_S' - W_L'}[1-e^{-r[T-E]}] \qquad (12)$$

Here $\Delta(\alpha)$ captures the minimum time spent earning the new skilled premium that is necessary to cover the cost of education. This cost (represented by $[e^{rE}-1][\beta W_S' + W_L']$) is the same for all upgraders, but the skill premium ($\alpha W_S' - W_L'$) is positively related to the upgrader's ability. More able workers can cover this cost more quickly, and therefore the

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[13] The decision to upgrade is based on a comparison of the discounted net benefits from being skilled with the discounted lifetime income at wage W_L'. The gain depends on a comparison of the same net benefits with the alternative income at the higher wage W_L.

higher the ability level the older the eldest worker that still finds skill upgrading attractive. Note that $\Delta(\alpha)$ is decreasing in α, and that $\Delta(\tilde{\alpha}') = 1 - e^{-r[T-E]}$ so that $t(\tilde{\alpha}') = 0$ - i.e. only new entrants upgrade at the new ability threshold. Again not all upgraders gain from the liberalisation. The eldest worker of ability α who does so is aged $\hat{t}(\alpha)$, where

$$\hat{t}(\alpha) = T - E + \frac{1}{r}\ln[1 - \hat{\Delta}(\alpha)] \tag{13}$$

and $\quad \hat{\Delta}(\alpha) \equiv \dfrac{[e^{rE} - 1][\beta W_S' + W_L]}{\alpha W_S' - W_L} \tag{14}$

here $\hat{\Delta}(\alpha)$ has an analogous interpretation to $\Delta(\alpha)$ [14] It is straightforward to establish that $t(\alpha) > \hat{t}(\alpha)$ [15] - i.e. for each ability level there is a range of older upgraders who are worse off after the liberalisation.
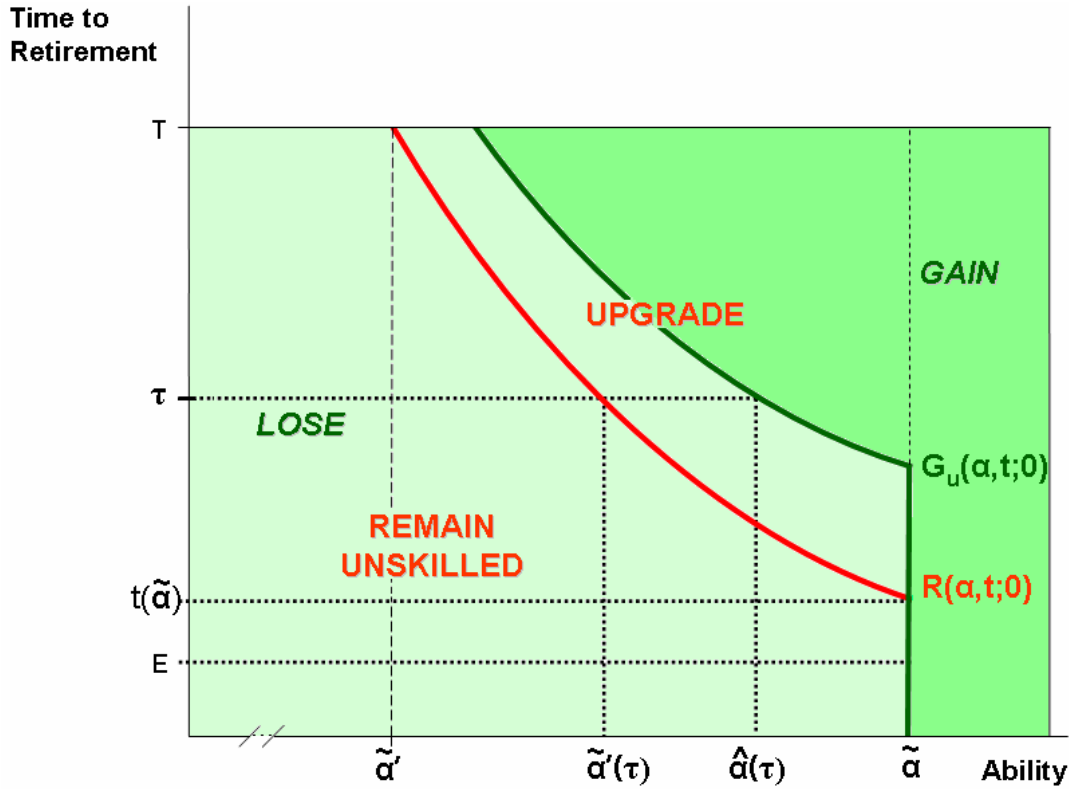

Figure 2: Upgraders, Gainers and Losers from an Unannounced trade Liberalisation

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[14] The (hypothetical) comparison here is between upgrading at the post-liberalisation skilled wage and remaining unskilled at the pre-liberalisation unskilled wage.

[15] Since $\partial \Delta(\alpha)/\partial W_L > 0$ and $W_L > W_L'$, we have $\hat{\Delta}(\alpha) > \Delta(\alpha)$ and therefore $1 - \hat{\Delta}(\alpha) < 1 - \Delta(\alpha)$. Subtracting (13) from (11) then gives $t(\alpha) > \hat{t}(\alpha)$.

These results are summarised in Propositions 1 and 2 below, and are illustrated in Figure 2, where ability is measured on the horizontal axis and time to retirement ($T-t$) on the vertical. $R(\alpha,t;0)$ shows combinations of age and ability where skill upgrading breaks even, and $G(\alpha,t;0)$ the corresponding combinations that imply no gain or loss from the liberalisation. Workers with characteristics above $R(\alpha,t;0)$ upgrade; those with characteristics above $G(\alpha,t;0)$ gain. Figure 2 also illustrates the characteristics of those who upgrade (adjust) but are worse off as a result of the liberalisation. These are the least able upgraders in each age cohort or, equivalently, the oldest upgraders in each ability cohort. Consider, for example, workers aged τ. Those whose ability lies in the range $\tilde{\alpha} - \tilde{\alpha}'(\tau)$ will upgrade, but of these only the subgroup $\tilde{\alpha} - \hat{\alpha}(\tau)$ will be better off as a result of the liberalisation. Those with ability less than $\tilde{\alpha}'(\tau)$ will remain unskilled.

> *Proposition 1. An unanticipated trade liberalisation in a small skilled-labour abundant country leads to: (a) gains to all existing skilled workers, with larger gains for younger more able workers; (b) gains to all existing students, with larger gains to more able students and the largest gain in each ability cohort to those just completing their training at the time of liberalisation; (c) losses to all continuing unskilled workers, with larger losses to younger workers.*
>
> *Proposition 2. An unanticipated trade liberalisation in a small skilled-labour abundant country leads to skill upgrading by some existing unskilled workers. Only workers with ability above the new steady-state cutoff will upgrade, and within this range there is an age-ability tradeoff, with younger or more able workers most likely to upgrade. Not all upgraders gain (relative to the pre-liberalisation equilibrium), and in any given ability cohort it is the older upgraders who lose.*

3.4. Long run adjustments in factor supplies

Liberalisation leads to a fall in the ability threshold and thus an increase in the number of skilled workers and a fall in the number of unskilled workers. The new long run equilibrium supply of skilled and unskilled labour can be determined by replacing $\tilde{\alpha}$ with $\tilde{\alpha}'$ in (7A) to (7D). The changes in the relevant supplies are

$$L' - L = (\tilde{\alpha}' - \tilde{\alpha})N < 0$$

$$S' - S = (\tilde{\alpha} - \tilde{\alpha}')\left[\frac{(\tilde{\alpha} + \tilde{\alpha}')}{2}(1 - \frac{E}{T})\right]N > 0$$

But with more students and the same number of teachers *per* student, more units of skill are diverted to education – i.e.

$$S'_E - S_E = (\tilde{\alpha} - \tilde{\alpha}')\frac{\beta E}{T}N > 0$$

The change in the supply of skilled labour available for traded goods is then[16]:

$$S'_M - S_M = [\tilde{\alpha} - \tilde{\alpha}']\left[[\frac{\tilde{\alpha} + \tilde{\alpha}'}{2}][1 - \frac{E}{T}] - \frac{\beta E}{T}\right]N > 0$$

These are the changes that take place in the long run[17]. The long run effects on the composition of trade goods production follows from the Rybczynski Theorem – output of the relatively skilled-labour intensive good increases and output of the other good falls. This is consistent with the findings of FK and Borsook, and models of variable factor supplies in a H-O-S setting (e.g. Martin, 1976; Neary, 1978, Woodland, 1982).

4. An Announced Liberalisation

We now consider skill upgrading where the government announces (at time 0) a trade liberalisation that will take place at a known point in the future (t_0). Agents accord this full credibility and we suppose that the prevailing wage rates after the liberalisation are as in the previous section. Since this liberalisation will raise the return to becoming skilled, some unskilled workers will choose to upgrade. Our objective in this section is to determine which agents working unskilled at the time of the announcement will choose to upgrade and when.

4.1. Upgrading strategies

We begin by looking at the timing of the upgrading decision for current unskilled workers. They have three alternative strategies available: (1) upgrade immediately; (2) upgrade just prior to the liberalisation (so as to be able to take advantage of the higher skilled wage as

---

[16] Note that $\left[\frac{\tilde{\alpha} + \tilde{\alpha}'}{2}\right]\left[1 - \frac{E}{T}\right] - \beta\frac{E}{T}$ is the net skilled labour supply of the average marginal skilled worker from the two long run equilibria.

[17] The medium run dynamics reflect the adjustment of the workforce existing at the time of the liberalisation and its progression towards retirement. They are omitted here, but are available from the authors.

soon as it is available); or (3) upgrade immediately after the liberalisation [18]. The corresponding income streams for an agent of ability α and age t at the time of the announcement are, respectively:

$$I_1(\alpha,t;t_0) = -\int_0^E \beta W_S e^{-rz} dz + \int_E^{t_0} \alpha W_S e^{-rz} dz + \int_{t_0}^{T-t} \alpha W_S' e^{-rz} dz \qquad (15A)$$

$$I_2(\alpha,t;t_0) = \int_0^{t_0-E} W_L e^{-rz} dz - \int_{t_0-E}^{t_0} \beta W_S e^{-rz} dz + \int_{t_0}^{T-t} \alpha W_S' e^{-rz} dz \qquad (15B)$$

$$I_3(\alpha,t;t_0) = \int_0^{t_0} W_L e^{-rz} dz - \int_{t_0}^{t_0+E} \beta W_S' e^{-rz} dz + \int_{t_0+E}^{T-t} \alpha W_S' e^{-rz} dz \qquad (15C)$$

We can establish ranges of ability over which each alternative will be preferred. Note that t affects each of these flows in exactly the same way. The period of earning the post-liberalisation skilled wage is shorter the older the worker at the time of the announcement. So as long as all three are viable for a given agent, her preferences over them will be independent of her age.

The agent's preferences between upgrading immediately or just prior to the liberalisation will be determined by

$$I_1 - I_2 = -\int_0^E [W_L + \beta W_S] e^{-rz} dz + \int_E^{t_0-E} [\alpha W_S - W_L] e^{-rz} dz + \int_{t_0-E}^{t_0} [\alpha W_S + \beta W_S] e^{-rz} dz$$

$$= \frac{[e^{rt_0} - e^{rE}]}{re^{rt_0}} \left\{ \frac{[\alpha+\beta]W_S}{e^{rE}} - [W_L + \beta W_S] \right\} \qquad (16)$$

Note that $t_0 > E$ for the distinction between these options to be meaningful, and that (16) is increasing in α. The difference between the two strategies is clear. If the agent upgrades immediately the opportunity cost (relative to continuing to work as unskilled and upgrading later) is W_L, and then the agent's earnings depend on their ability and the current skilled wage. If the agent upgrades later, the cost of education is deferred but their earnings in the meantime are the current unskilled wage and the opportunity cost of upgrading is their

---

[18] Any strategy dividing the education period before and after the liberalisation is dominated by either all before or all after depending on ability.

foregone skilled earnings (αW_S). The agent indifferent between these two alternatives has ability α_{12} where

$$\alpha_{12} W_S - W_L = [e^{rE} - 1][\beta W_S + W_L] \tag{17}$$

One can show that $\tilde{\alpha} > \alpha_{12} > \alpha_0$, so that an agent on the margin of becoming skilled under the pre-liberalisation regime will prefer I_1 to I_2 once the liberalisation is announced. An agent who would earn the same whether skilled or unskilled under the pre-liberalisation factor prices (i.e. an agent of ability α_0) would prefer to defer the cost of education.

The agent's preferences between upgrading just before and just after the liberalisation are determined by:

$$
\begin{aligned}
I_2 - I_3 &= -\int_{t_0 - E}^{t_0} [W_L + \beta W_S] e^{-rz} dz + \int_{t_0}^{t_0 + E} [\alpha W_S' + \beta W_S'] e^{-rz} dz \\
&= \frac{[e^{rE} - 1]}{re^{rt_0}} \left\{ \frac{[\alpha + \beta] W_S'}{e^{rE}} - [W_L + \beta W_S] \right\}
\end{aligned} \tag{18}
$$

Again this comes down to a comparison of discounted education costs. The advantage of delayed upgrading is that these costs are further in the future. The disadvantage is that both the direct cost and the opportunity cost (i.e. working as skilled under the new wage structure) are higher. The agent indifferent between these two alternatives has ability α_{23} where

$$[\alpha_{23} + \beta] W_S' = e^{rE}[\beta W_S + W_L] \tag{19}$$

One can show that $\alpha_{12} > \alpha_{23}$. Since both (16) and (18) are increasing in α, we have established that I_1 is the preferred option for upgraders in the ability range $\tilde{\alpha} > \alpha \geq \alpha_{12}$, I_2 is the preferred option for upgraders in the ability range $\alpha_{12} > \alpha \geq \alpha_{23}$, and I_3 is the preferred option for upgraders in the ability range $\alpha_{23} > \alpha > \tilde{\alpha}'$. Thus we have

> *Proposition 3. Workers who choose to upgrade in response to an announced liberalisation to take place in the future, will prefer one of three upgrading strategies, depending on their ability, but independent of their age:*
>
> *(i) those most able among workers whose pre-liberalisation skill premium was positive will prefer to upgrade immediately following the announcement;*

(ii) those in an intermediate skill range will prefer to upgrade immediately before the liberalisation; and

(iii) those closest to the new steady-state ability cutoff will prefer to upgrade immediately after the liberalisation.

We noted that these cutoffs are independent of the worker's age. Equations (17) and (19) reveal that they are also independent of the proximity of the liberalisation (t_0). Further, we see from (17) that the cutoff between strategies I_1 and I_2 is independent of the size of the liberalisation, and hence independent of the new steady state threshold ability. Thus if we compare

$$\tilde{\alpha} - \alpha_{12} = \frac{e^{rE}[e^{rE} - 1]}{[e^{rT} - e^{rE}]} \frac{[\beta W_S + W_L]}{W_S} \qquad \text{and}$$

$$\tilde{\alpha} - \tilde{\alpha}' = \frac{e^{rE}[e^{rT} - 1]}{[e^{rT} - e^{rE}]} \left[\frac{W_L}{W_S} - \frac{W_L'}{W_S'} \right]$$

We can see that $\tilde{\alpha}' > \alpha_{12}$ if the liberalisation is sufficiently small – i.e. if

$$\frac{[e^{rE} - 1]}{[e^{rT} - 1]} \frac{[\beta W_S + W_L]}{W_S} > \left[\frac{W_L}{W_S} - \frac{W_L'}{W_S'} \right] \qquad (20A)$$

In this case *all* upgraders among the existing workforce would prefer to do so immediately the liberalisation is announced. In contrast from (19) we see that the cutoff between strategies I_2 and I_3 is influenced by the size of the liberalisation. A larger liberalisation implies that both $\tilde{\alpha}'$ and α_{23} are smaller, the latter because the (direct and opportunity) cost of education is higher under strategy I_3. Again it is possible that $\tilde{\alpha}' > \alpha_{23}$, this time if

$$\frac{[\beta W_S' + W_L']}{[\beta W_S + W_L]} > \frac{[e^{rT} - e^{rE}]}{[e^{rT} - 1]} \qquad (20B)$$

In this case all upgraders among the existing workforce would prefer to upgrade before the liberalisation occurs. Note that the right side of this inequality is less than unity, which implies that if the cost of becoming skilled is higher post-liberalisation, then all upgrading will occur prior to the liberalisation. These outcomes are summarised in:

Proposition 4. Suppose a liberalisation is announced to take place more than E periods into the future. If (a) the liberalisation is sufficiently small or (b) the cost of

upgrading is higher after the liberalisation, then all induced skill-upgrading by the existing workforce will take place before the liberalisation occurs.

4.2. Returns to upgrading

Having established their preferred options should they choose to upgrade, we now consider the returns from skill upgrading for each group. These will depend on worker age. For a given size and proximity of liberalisation we wish to determine for each ability cohort, the maximum age for which an existing worker will find skill upgrading profitable. Clearly under options I_1 and I_2 this must be bounded by $T - t_0$, since workers of this age or older will have left the labour force before the liberalisation occurs. For option I_3 the bound is $T - t_0 - E$ since the worker would not complete schooling until E periods after the liberalisation. The returns to skill upgrading under the three options for a worker of ability α and age t, when a liberalisation occurs t_0 periods in the future are given by, respectively:

$$R_1(\alpha,t;t_0) = -\int_0^E [\beta W_S + W_L]e^{-rz}dz + \int_E^{t_0} [\alpha W_S - W_L]e^{-rz}dz + \int_{t_0}^{T-t} [\alpha W_S' - W_L']e^{-rz}dz \quad (21A)$$

$$R_2(\alpha,t;t_0) = -\int_{t_0-E}^{t_0} [\beta W_S + W_L]e^{-rz}dz + \int_{t_0}^{T-t} [\alpha W_S' - W_L']e^{-rz}dz \quad (21B)$$

$$R_3(\alpha,t;t_0) = -\int_{t_0}^{t_0+E} [\beta W_S' + W_L']e^{-rz}dz + \int_{t_0+E}^{T-t} [\alpha W_S' - W_L']e^{-rz}dz \quad (21C)$$

It is clear that $R_j(\alpha,t;t_0)$, $j=1,2,3$ is lower the older a worker of given ability[19]. If we set $R_j(\alpha,t;t_0) = 0$, we can solve for the maximum age ($t_j(\alpha;t_0)$) at which a worker of ability α would find upgrading worthwhile under option j. These solutions are given by

$$t_j(\alpha;t_0) = T - t_0 + \frac{1}{r}\ln[1-\Delta_j(\alpha)] \quad (j=1,2); \quad t_j(\alpha;t_0) = T - t_0 - E + \frac{1}{r}\ln[1-\Delta_3(\alpha)] \quad (22)$$

where

$$\Delta_1(\alpha) = \frac{e^{rt_0}[e^{rE}-1][\beta W_S + W_L] - [e^{rt_0}-e^{rE}][\alpha W_S - W_L]}{e^{rE}[\alpha W_S' - W_L']} \quad (23)$$

---

[19] Since $\dfrac{\partial R_j(\alpha,t)}{\partial e^{rt}} = -\dfrac{[\alpha W_S' - W_L']}{r}e^{-rT} < 0$ in each case.

$$\Delta_2(\alpha) = \frac{[e^{rE}-1][\beta W_S + W_L]}{\alpha W_S' - W_L'}; \qquad \Delta_3(\alpha) = \frac{[e^{rE}-1][\beta W_S' + W_L']}{\alpha W_S' - W_L'}$$

The interpretations of $\Delta_2(\alpha)$ and $\Delta_3(\alpha)$ are straightforward - they represent the minimum time spent working at the new skill premium necessary to offset the cost of upgrading. A similar interpretation applies to $\Delta_1(\alpha)$, once one takes into account that these upgraders had a period spent earning a positive skill premium prior to the liberalisation. $\Delta_1(\alpha)$ represents the minimum time spent earning the new skill premium that is required to offset the total costs of education that are not covered by earnings at the old skill premium[20]. Inspection reveals that $\partial \Delta_j(\alpha)/\partial \alpha < 0$ and therefore $\partial t_j(\alpha)/\partial \alpha > 0$ within each range, and it is straightforward to show that the solutions to (22) have $t_1(\tilde{\alpha}) > t_1(\alpha_{12}) = t_2(\alpha_{12}) > t_2(\alpha_{23}) = t_3(\alpha_{23})$. We would expect to observe a decline in the age of the oldest worker upgrading as we consider workers of lower ability. Of course $t_j(\alpha) = 0$ will occur at some point in the range $[\tilde{\alpha}, \tilde{\alpha}']$, depending on the proximity of the liberalisation and its size. No current workers of lower ability will then upgrade.

---

[20] The costs of education and earnings from the old skill premium (both discounted to time 0) are respectively $[1 - e^{-rE}][\beta W_S + W_L]$ and $[e^{-rE} - e^{-rt_0}][\alpha W_S - W_L]$. If we subtract the second from the first and then multiply the outcome by e^{rt_0}, we have the "education cost deficit" at the time of the liberalisation. If we then divide this by the new skill premium $[\alpha W_S' - W_L']$, we have the minimum time necessary earning the new skill premium to offset this deficit. $\Delta_1(\alpha)$ is simply a rearrangement of this term.
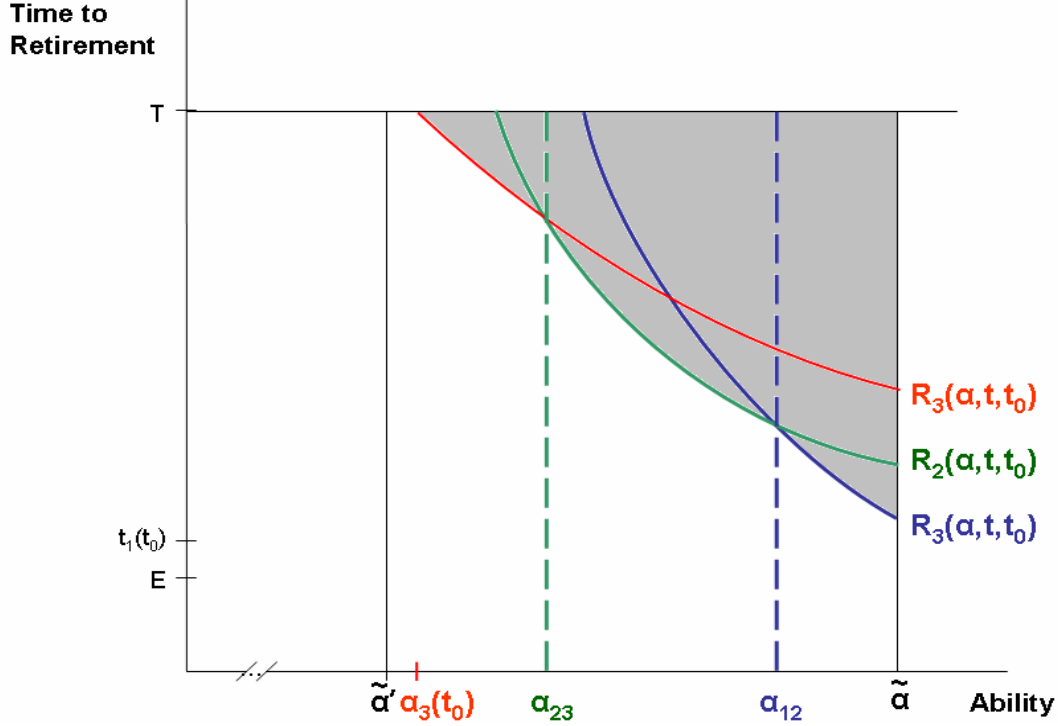
Figure 3: Upgrading in Response to an Announced Trade Liberalisation

These outcomes are illustrated in Figure 3. The pre-liberalisation steady state ability cutoff is given by $\tilde{\alpha}$ and the post-liberalisation steady state cutoff by $\tilde{\alpha}'$. We assume that the liberalisation is sufficiently large that some existing workers will prefer each of the three upgrading strategies, at least when the liberalisation is sufficiently proximate. In this figure each $R_j(\alpha,t;t_0)=0$ is negatively sloped since both ability and youth raise the return to skill upgrading. Further, we can show that, for any common $(\alpha,T-t)$, R_j is steeper than R_{j+1} - i.e.[21]

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[21] As noted above a change in T-t has the same effect on returns under all three strategies $\partial R_j/\partial[T-t] = [\alpha W_S' - W_L']/e^{-r[T-t]} > 0$, j = 1,2,3. The difference lies in the effects of a change in ability. A higher ability increases the return under strategy I_1 through a higher skill premium both before and after the liberalisation. The former effect is absent from the other strategies. The discounted post-liberalisation skill premium is the same under strategies I_1 and I_2, and is smaller under strategy I_3 because the period during which it is earned is shorter due to upgrading being undertaken after the liberalisation. Thus

$$\partial R_2/\partial\alpha = -[W_S'/r]\left[e^{-r[T-t]} - e^{-rt_0}\right] > 0; \qquad \partial R_3/\partial\alpha = -[W_S'/r]\left[e^{-r[T-t]} - e^{-r[t_0+E]}\right] > 0; \qquad \text{and}$$

$$\partial R_1/\partial\alpha = \partial R_2/\partial\alpha - [W_S/r]\left[e^{-rt_0} - e^{-rE}\right] > \partial R_2/\partial\alpha .$$

$$\left|\frac{\partial[T-t]}{\partial\alpha}\right|_{R_1} > \left|\frac{\partial[T-t]}{\partial\alpha}\right|_{R_2} > \left|\frac{\partial[T-t]}{\partial\alpha}\right|_{R_3}$$

The more proximate the liberalisation the longer the period spent earning the new skill premium and hence the higher the return to skill upgrading at any ability-age combination. This implies that the $R_j(\alpha,t;t_0)=0$ schedules shift down as t_0 falls, maintaining their points of intersection at the crossover abilities established above.

The announcement of a liberalisation that would not take place during the working life of the existing labour force (i.e. $t_0 \geq T$) will induce no upgrading by them. However, any t_0 such that $T > t_0 \geq 0$ will induce upgrading by some workers, as illustrated by the shaded area in Figure 4. As noted above, those workers in this area with ability in the range $\tilde{\alpha} \geq \alpha > \alpha_{12}$ will upgrade immediately the announcement is made, those in the range $\alpha_{12} \geq \alpha > \alpha_{23}$ will plan to upgrade just before the liberalisation occurs, and those in the range $\alpha_{23} \geq \alpha > \alpha_3(t_0)$ just after. The worker of lowest ability who plans to upgrade is a new entrant ($T-t=T$) with ability

$$\alpha_3(t_0) = \tilde{\alpha}' + \left[\frac{\tilde{\alpha}'W_S' - W_L'}{W_S'}\right]\left[\frac{e^{r[t_0+E]} - e^{rE}}{e^{rT} - e^{r[t_0+E]}}\right] \geq \tilde{\alpha}' \tag{24}$$

The oldest worker who upgrades does so immediately and has ability $\tilde{\alpha}$ and from (22) age

$$t_1(\tilde{\alpha};t_0) = T - t_0 + \frac{1}{r}\ln\left[1 - \Delta_1(\tilde{\alpha};t_0)\right] < T - t_0 \quad \text{and} \quad \Delta_1(\tilde{\alpha};t_0) = \frac{[\tilde{\alpha}W_S - W_L]}{[\tilde{\alpha}W_S' - W_L']}\frac{e^{rT} - e^{rt_0}}{e^{rT}}$$

The larger and more proximate the liberalisation the older the eldest worker who upgrades (i.e. $t_1(\tilde{\alpha};t_0)$ converges towards $T - t_0$ from above as the liberalisation becomes larger).

However, once $t_0 = E$ strategies I_1 and I_2 become identical. An even more proximate liberalisation ($t_0 < E$) means that upgrading cannot be completed before it occurs, and the only strategies available are I_3 and upgrading immediately but paying part of the costs of education at the old factor prices and the remainder at the new. Clearly for an immediate liberalisation only I_3 is available, in which case $\alpha_3(0) = \tilde{\alpha}'$. At the other end of the ability range ($\tilde{\alpha}$), it is straightforward to compare the oldest worker who upgrades (under strategy

21

I_1) when $t_0 = E$, with the oldest worker who upgrades (under strategy I_3) when $t_0 = 0$. In each case the relevant worker begins skill upgrading immediately and enters the labour market as a skilled worker E periods later. The difference between the two is that in the former case education is incurred at the old factor prices while in the latter case it is incurred at the new. Education is more costly post-liberalisation if $\beta[W_S' - W_S] > [W_L - W_L']$ in which case $t_1(\tilde{\alpha}; E) > t_3(\tilde{\alpha}; 0)$.

But like an unannounced liberalisation, not all upgraders are better off than they would have been if the liberalisation did not take place. The gain from liberalisation under upgrading strategy j can be determined from

$$G_j(\alpha, t; t_0) = I_j(\alpha, t; t_0) - I_0(t), \qquad \text{where } I_0(t) = \int_0^{T-t} W_L e^{-rz} dz \qquad (25)$$

Here $I_0(t)$ represents the (hypothetical) income that would have been earned had the liberalisation not taken place. It is then straightforward to show that the difference between the gain from liberalisation and the return to upgrading is the same across the three upgrading strategies – i.e.

$$G_j(\alpha, t; t_0) - R_j(\alpha, t; t_0) = \frac{[W_L' - W_L]}{r} \left[\frac{e^{r[T-t]} - e^{rt_0}}{e^{r[T-t]} e^{rt_0}} \right] < 0$$

Since this involves a comparison as an unskilled worker at the pre- and post-liberalisation wages it is independent of ability. The gain is always less than the return, implying that, at each ability level, the marginal upgrader is worse off as a result of the liberalisation. The older the worker or the less proximate the liberalisation, the smaller the difference. The oldest worker who gains at each ability level can be determined in the same way as the oldest worker who upgrades, by solving $G_j(\alpha, t; t_0) = 0$ for $\hat{t}_j(\alpha; t_0)$. The solutions are as given by (22) and (23) above, if $\alpha W_S' - W_L'$ is replaced by the smaller quantity $\alpha W_S' - W_L$.

4.3. Adjustments to factor supplies

The long run outcomes (i.e. when the existing labour force has retired) will be the same for an announced liberalisation of the same magnitude as the unanticipated liberalisation considered in Section 3. The medium run adjustments will differ, however, depending on

the size and proximity of the announced liberalisation[22]. The intriguing outcome under the announced liberalisation is that some, or even all, of the skill upgrading by the existing workforce will occur before the liberalisation itself. The increase (decrease) in the supply of skilled (unskilled) labour will increase the output of the skill-labour intensive exportable and decrease the output of the unskilled-labour intensive importable, via the Rybczynski theorem. Thus a significant part of the adjustment in the trade volume "induced" by the liberalisation may occur before the liberalisation itself. As noted above, this prediction is confirmed by the evidence in Freund and McLaren (1999).

5. Should a Liberalisation be Announced?

One interesting implication of the analyses in the preceding two sections is that no existing worker will prefer an unanticipated liberalisation. To make the comparison more precise, if a government is considering a liberalisation at some future date t_0 ($t_0 > E$), then all existing workers will have a (weak) preference that the date of liberalisation be announced immediately rather than kept secret and then an unanticipated liberalisation occur at t_0. Those workers who would not change status and those who would optimally choose to upgrade after the liberalisation are indifferent. Those who would optimally upgrade before the liberalisation clearly prefer that it is announced.

This result can be formalised by comparing the upgrading outcomes under an unannounced (and unanticipated) liberalisation with those under a *fully anticipated* liberalisation. Since the optimal upgrading strategy can involve upgrading on entry, a fully anticipated liberalisation must have been anticipated by all workers when they entered the labour force. This comparison will also allow us to identify those workers with "regrets", particularly those who would have upgraded had they anticipated the liberalisation, but who do not find upgrading worthwhile after an unanticipated liberalisation. Of course these are not the only workers with regrets, since some of those who still upgrade would have done so earlier had they anticipated the liberalisation.

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[22] Again, details of the adjustment under an announced liberalisation are available from the authors.

23

Consider any worker of age t in the labour force at the time that the unanticipated liberalisation occurs. Had this worker known, at the time she entered the labour force, when the liberalisation was going to occur, she would have had the three options for the timing of upgrading discussed in the previous section. Determining the worker's preferred option involves the same comparisons as in the previous section (if we set $t_0 = t$ and $t = 0$). Thus the preference depends only on the worker's ability. Those for whom $\tilde{\alpha} \geq \alpha > \alpha_{12}$ would have upgraded immediately on entering the workforce; those for whom $\alpha_{12} \geq \alpha > \alpha_{23}$ would have entered unskilled but upgraded immediately before the liberalisation; and those for whom $\alpha_{23} \geq \alpha > \tilde{\alpha}'$ would have entered unskilled and only upgraded once the liberalisation had occurred. Clearly the latter group can have no regrets since their preferred action is the same whether the liberalisation is anticipated or not.

We have derived the return from upgrading for anticipated and unanticipated liberalisations in the previous sections. In each case the return is increasing in ability but declining in age. For each ability level therefore we can solve for the oldest worker (at the time of the liberalisation) who would have found it worthwhile to upgrade for an anticipated liberalisation and compare this with the oldest worker who finds upgrading profitable after an unanticipated liberalisation of the same size. For the former this involves solving $R_j(\alpha, 0; t) = 0$ for $t_j(\alpha)$, which is straightforward for strategies I_2 and I_3 but less so for I_1 as now 't', which represents both the worker's age and the time at which the liberalisation takes place, determines the division of working time spent earning at the old and the new skill premia. The solution is most readily interpretable if we rewrite $R_1(\alpha, 0; t)$ as

$$R_1(\alpha,0;t) = -\int_0^E [\beta W_S + W_L]e^{-rz}dz + \int_E^T [\alpha W_S - W_L]e^{-rz}dz$$
$$+ \int_t^T \{[\alpha W_S' - W_L'] - [\alpha W_S - W_L]\}e^{-rz}dz \tag{26}$$

The first two terms on the right of (26) represent the net return from upgrading at the pre-liberalisation factor returns. We know that this is negative for $\alpha < \tilde{\alpha}$. The final term in (26) is the additional income from the higher skill premium post-liberalisation, and depends on t, the age of the worker when the liberalisation occurs. The oldest worker who upgrades under strategy I_1 is determined where the final term offsets the first two. We therefore have

24

$$t_1(\alpha) = T - \frac{1}{r}\ln[1 + \Delta_1^R(\alpha)], \quad t_2(\alpha) = T + \frac{1}{r}\ln[1 - \Delta_2^R(\alpha)] \; ; t_3(\alpha) = T - E + \frac{1}{r}\ln[1 - \Delta_3^R(\alpha)]$$

Where $\Delta_2^R(\alpha)$ and $\Delta_3^R(\alpha)$ are as defined in (23) above and

$$\Delta_1^R(\alpha) = \frac{e^{r[T-E]}[e^{rE} - 1][\beta W_S + W_L] - [e^{r[T-E]} - 1][\alpha W_S - W_L]}{[\alpha W_S' - W_L'] - [\alpha W_S - W_L]}$$

Here $\Delta_1^R(\alpha)$ reflects the minimum time required earning the increase in the skill premium to offset the deficit in the return to skill upgrading at the old factor prices. The comparison with an unanticipated liberalisation is facilitated by noting that $e^{-rt}R_3(\alpha, 0; t) = R_3(\alpha, t; 0)$, so that when these are equated to zero the oldest worker who finds it profitable to upgrade under strategy I_3 after an anticipated liberalisation is the same as the oldest worker who finds it profitable to upgrade after an unanticipated liberalisation at this ability level. Note that each $\Delta_j^R(\alpha)$ is decreasing in α, and that it is straightforward to show that $\Delta_1^R(\tilde{\alpha}) = 0$, so that $t_1(\tilde{\alpha}) = T$ - i.e. all workers at the old ability threshold would have upgraded had they anticipated the liberalisation; $1 - \Delta_3^R(\tilde{\alpha}') = e^{-r[T-E]}$, so that $t_3(\tilde{\alpha}') = 0$ - i.e. at the new ability threshold, only new entrants at the time of the liberalisation will upgrade; $t_1(\alpha_{12}) = t_2(\alpha_{12})$ and $t_2(\alpha_{23}) = t_3(\alpha_{23})$. The comparison of upgrades under anticipated and unanticipated liberalisations is shown in Figure 4.
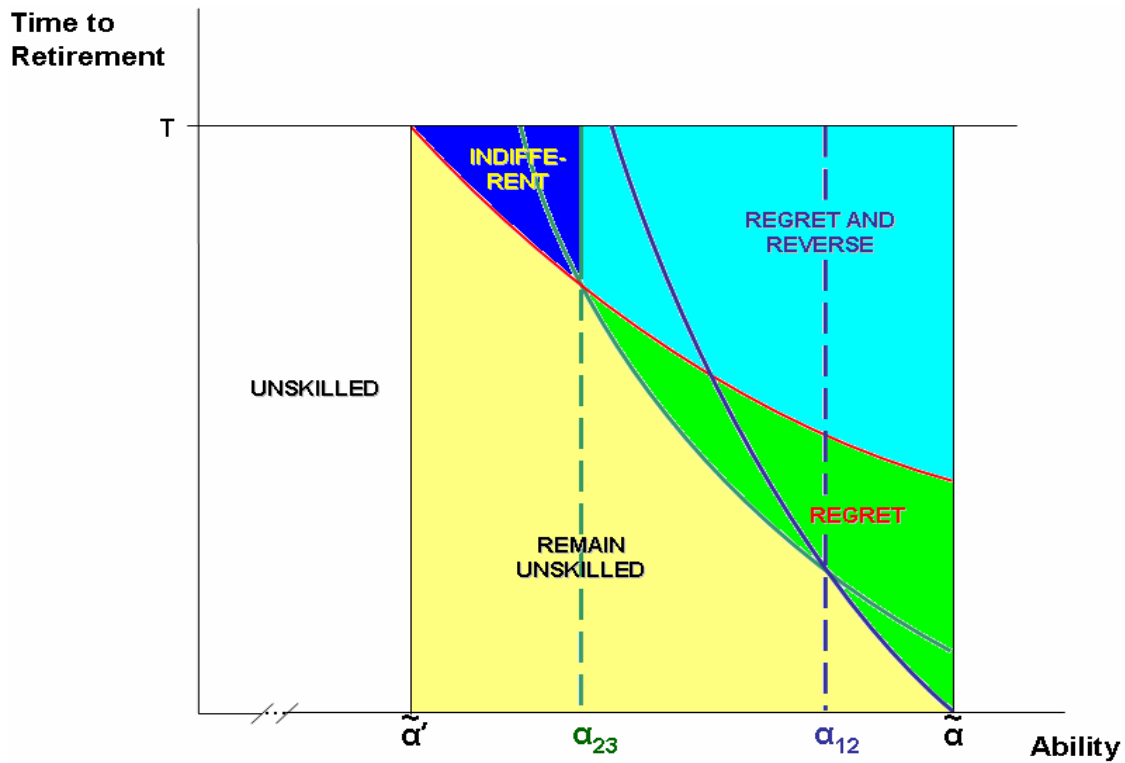
Figure 4: Regrets and Reversals

If the timing and size of the liberalisation are fully known to entrants at the time they enter then those whose ability and working age at the time of the liberalisation places them above the $\min\{R_j(\alpha,0;t)=0, j=1,3\}$ boundary will upgrade at the optimal time. If the liberalisation is not anticipated, then only those workers whose ability and working age at the time of the liberalisation place them above the $R_3(\alpha,0;t)=0$ boundary will upgrade. This implies that workers in the ability range $[\tilde{\alpha}$ to $\tilde{\alpha}']$ can be divided into four categories: (a) those who choose to *remain unskilled* whether they anticipate the liberalisation or not; (b) those for whom I_3 is the preferred strategy anyway and hence are *indifferent* between an anticipated and an unanticipated liberalisation; (c) those who upgrade in each case, but would prefer to use either strategy I_1 or I_2 for an anticipated liberalisation - these workers *regret and reverse* their decision to remain unskilled if an unanticipated liberalisation occurs; and (d) those who would have upgraded under strategies I_1 or I_2 if they had anticipated the liberalisation and who *regret* but do not reverse the decision to remain unskilled for an unanticipated liberalisation. These workers tend to be older than those in (c). The location of each of these groups is indicated in Figure 4. Of course, the regrets by

some unskilled workers who remain unskilled, and by others that they had not upgraded earlier, are not adjustment costs of the policy change, but may be important for its reception and the political economy of its long run success. We summarise these results in:

> *Proposition 5: if a liberalisation is to undertaken at a fixed date in the future, all workers will (weakly) prefer that it is announced in advance rather than left unanticipated.*

> *Corollary: there is less skill-upgrading by the existing work force if the liberalisation is unanticipated than if it is anticipated.*

These results have established a case for announcing a liberalisation that is to take place at a known point in the future. What they do not establish, of course, is that a delayed, but announced liberalisation is preferred to an immediate, but unannounced liberalisation. Skilled workers clearly prefer that the liberalisation occurs as early as possible, unskilled workers that it be delayed as long as possible. Likewise, of those workers induced to upgrade by the liberalisation, some gain and some lose, so some will prefer that it occurs early and others that it occurs later. From an aggregate welfare perspective, trade barriers are the only source of distortion here. They cause the domestic relative price of the importable to exceed its world relative price, which represents the shadow price for this small country. Production and consumption decisions are distorted as a consequence. Further, the higher relative price of the importable increases the (real) wage to unskilled labour and reduces the (real) wage to skilled labour relative to their shadow values, distorting the upgrading decision towards insufficient skill acquisition[23]. Under our assumptions (of no short run adjustment costs in particular), removal of the trade barriers corrects the consumption and production distortions. It also ensures that both new entrants to the labour market and existing workers make their upgrading decisions facing shadow prices, hence their private decisions are now also socially optimal. Less than complete removal of the trade barriers will mean that consumption, production and upgrading decisions are still made under distorted prices (even if the distortion has been reduced). This leaves us firmly in the realm of the second best and we cannot say a priori whether a delay of the liberalisation, which may induce greater upgrading amongst the existing

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[23] In principle this distortion, which is unlikely to form part of the political economy motivation for these trade barriers, can be corrected by an appropriate subsidy to skill acquisition.

workforce but which leaves the production and consumption distortions at higher levels, will lead to a welfare superior outcome to an immediate liberalisation.

6. Adjustment Assistance

In this section we briefly discuss some issues that our analysis raises for the design and implementation of a program of "adjustment assistance" intended to compensate those workers who are not net gainers from the liberalisation *and* who undertake costly adjustment. Obviously this is not, and is not intended to be, a general model of adjustment to trade liberalisation. Along with skill upgrading, trade liberalisation in this model involves the reallocation of workers between sectors, which we have assumed to take place instantaneously and costlessly. This is of course unrealistic, but is a necessary simplification if we are to focus on the adjustment through skills upgrading.

Governments do not provide specific schemes of redistribution of the gains from trade[24]. Some redistribution may happen indirectly, through general taxation of the gainers and social welfare payments to the losers (should their losses consign them to the social safety net). Where special assistance may be provided is to those who undertake costly adjustment as a result of the liberalisation. In this model these are the members of the existing workforce who choose to upgrade. The general assumption underlying such programmes is that worker adjustment that occurs in response to trade policy changes is involuntary and represents a cost imposed on a reluctant worker. As we have seen this is not necessarily the case. Among adjusters there are winners and losers: in particular the older workers in each ability cohort lose, whereas the younger workers gain. This result is consistent with Kletzers (2004) empirical findings.

6.1 An unanticipated liberalisation

Consider first the case of an unanticipated liberalisation. Then, as discussed in section 3, those workers whose return from upgrading is now positive will undertake it. Not all these workers are better off as a result of the liberalisation, but because the gains from upgrading are increasing in ability and decreasing in age, the age cutoff between those who gain and

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[24] Ichida (2005) provides a careful and detailed discussion of the difficulties in designing compensation schemes to redistribute the gains from trade through product and factor taxes and subsidies.

those who lose is increasing in ability. If both worker characteristics were observable, it would be straightforward to design a scheme that only compensated the losers. But while age is likely to be observable, ability is not ex ante. Nor would it be revealed by a worker's unskilled income, which is assumed to be independent of ability. Any scheme based on age alone is likely to fail to capture some losers with low ability while rewarding some gainers of higher ability.

6.2 An anticipated liberalisation

When we turn to an announced liberalisation, it is apparent that a poorly designed assistance scheme itself can introduce a distortion into the economy. Typically assistance is only provided to members of the existing workforce adjusting *after* the liberalisation has occurred. But, as we saw in section 4, for an announced liberalisation it is optimal for much of the upgrading to take place before the liberalisation. Those upgraders following strategies I_1 and I_2 will be ineligible for adjustment assistance, although these groups will contain (older) workers who are net losers from the liberalisation. The presence of adjustment assistance that is restricted to strategy I_3 then distorts the timing of upgrading as we now show. Since our objective is primarily illustrative, we restrict attention to the simplest case where (a) the full costs of upgrading (i.e. $\beta W_S'$ and W_L') are reimbursed to those members of the existing workforce who choose to upgrade *after* the liberalisation, and (b) the liberalisation itself is trivially small so that factor returns are unaffected. Clearly this is an extreme case, but we can rely on continuity to infer that similar outcomes will occur for significant education subsidies and a small liberalisation.

We begin by noting that an unanticipated liberalisation under this regime would see upgrading by all existing workers with ability $\alpha_0 < \alpha < \alpha'$ (where $\alpha_0 W_S = W_L$) and age $t < T - E$. Those with ability above the threshold will already have upgraded. Clearly, there will be some socially inefficient upgrading among the existing workforce. Now consider the announcement at time 0 of a (trivial) liberalisation to take place at time t_0, with full compensation of post-liberalisation adjustment costs. Since there will be no change in factor returns, the liberalisation itself generates no upgrading – i.e. there is no change in the steady state ability threshold. What will induce changes in upgrading behaviour is the

education subsidy. At the time of the announcement all existing workers whose ability was above the threshold had either upgraded (if $t > E$) or were undertaking schooling (if $t \leq E$). Those in schooling, and any subsequent entrants prior to the liberalisation have to decide whether to (continue to) upgrade now, paying the full cost, or to wait until after the liberalisation and upgrade for free. Consider the choice of a worker just entering the labour force at the time of the announcement. For this worker the benefits of upgrading immediately rather than at t_0 are given by

$$IM(\alpha,0;t_0) = -\int_0^E [\beta W_s + W_L]e^{-rz}dz + \int_E^{t_0+E} [\alpha W_s - W_L]e^{-rz}dz$$

The negative term is the costs of education and the positive term the benefits of earning the skill premium earlier. The entrant who is indifferent between the two strategies has ability α_A, where

$$\frac{\alpha_A W_S - W_L}{\tilde{\alpha} W_S - W_L} = \frac{e^{rt_0}[e^{r[T-E]}-1]}{e^{r[T-E]}[e^{rt_0}-1]}$$

This implies that $\alpha_A \geq \tilde{\alpha}$ as $t_0 \leq T - E$. Some new entrants who would otherwise have upgraded immediately will delay upgrading until after the liberalisation, as long as it is not so distant into the future that they would have no time working as a skilled worker. An anticipated future liberalisation accompanied by a program of adjustment assistance that only compensates for upgrading costs undertaken after the liberalisation, may lead to reductions in the numbers in schooling and a consequent increase in the unskilled workforce, prior to the liberalisation.

7. Conclusions

Our aim in this paper has been to highlight how the characteristics of the existing workforce, particularly the age and ability of unskilled workers, affects when and whether they opt for skill upgrading in response to a trade liberalisation. To this end we adapted the models of FK and Borsook to focus on medium term adjustments by the existing workforce. The conventional view is that trade liberalisation in a relatively skill abundant country makes all skilled workers better off and all unskilled workers worse off. Treating each occupational group as homogeneous ignores differences within them and, most significantly the possibility of mobility between groups.

Because trade liberalisation in a relatively skill abundant country increases the relative return to skilled labour, it induces some skill upgrading by existing unskilled workers. An unanticipated liberalisation will induce those close to the old ability threshold to upgrade. Because the return on upgrading is increasing in ability and decreasing in age, younger, more able workers are more likely to upgrade and older, less able workers to remain unskilled. While all upgraders become skilled as a result of the liberalisation, not all are better off than before. Specifically, for any given ability cohort the youngest workers upgrade and gain, an intermediate range upgrade but lose and the oldest remain unskilled (and lose). The balance among these three groups shifts towards the losers as we consider lower ability cohorts. These results confirm the widespread view that older workers are more likely to lose among the adjusters to trade liberalisation.

A similar pattern applies for an announced trade liberalisation. The most significant difference is that the announcement allows the option of upgrading prior to the liberalisation and this option will be preferred by those closest to the pre-liberalisation ability threshold and hence those most likely to upgrade. The implication is that if a liberalisation is anticipated, much of the adjustment - or indeed all of it if the liberalisation is small enough - will take place prior to the liberalisation itself. This has implications for both the empirical measurement of adjustment and the design of programs of adjustment assistance. Neither of these should be restricted to the post-liberalisation period.

The attitudes of workers to an unanticipated liberalisation will be influenced not only by its consequences for their incomes but also by what might have been. Using the results from anticipated and unanticipated liberalisations, we can see that all workers would (weakly) prefer that a liberalisation planned for a set date in the future is announced in advance. We are also able to identify those workers who would have upgraded prior to the liberalisation had they known it was coming when the entered the labour force, and to divide them into those who still upgrade and those who do not. Both subgroups regret the decision to remain unskilled but only the first reverse it. Again the composition of these groups depend on worker characteristics. Regardless of age, more able unskilled workers are more likely to

31

upgrade prior to the liberalisation. For any ability cohort older workers are less likely to reverse their entry decision to remain unskilled.

Whether it is anticipated or not any adjustment to a trade liberalisation via upgrading is a dynamic process that may take much longer than suggested by conventional analysis. The new factor returns imply a lower skilled labour ability threshold, and, although all existing unskilled workers could reverse their decision to remain unskilled, for older or less able workers it will not be attractive to do so. Until the new steady state is achieved (i.e. as long as the workforce contains individuals who entered prior to the liberalisation or its announcement), the supply of skilled (unskilled) labour in a skill-abundant country will be below (above) its long run level.

While in no way intending to offer a detailed analysis of adjustment assistance, our results suggest two important considerations for the design of such a program. First, some upgraders (adjusters) are gainers and some losers from trade liberalisation. There would seem to be little argument for compensating the former. Second, if liberalisation is anticipated, some adjustment optimally will occur before the liberalisation. Hence a program of adjustment assistance that provides subsidies of adjustment costs, but only after the liberalisation has occurred, will distort the timing of adjustment away from its optimal path.

There are several directions in which this work might usefully be extended in the future. The integration of short run adjustment costs would allow a more comprehensive consideration of adjustment assistance. Not all upgrading occurs via a formal schooling process. On-the-job training is an important alternative form of skill acquisition, often for skills that are firm or industry specific. Investigation of the effects of trade liberalisation on the demand for and supply of these types of skills requires a different model[25]. The range of

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[25] The effects of trade liberalisation on firm specific human capital formation have recently been analysed by Long et al. (2007). They note that firm specific human capital introduces a non-competitive element to wage determination, since a worker is more productive employed in a specific job, than by any other firm. They therefore assume that the wage of a skilled worker arises as the Nash bargaining solution between the worker and the firm. Firms do not take the wages of skilled workers as given therefore, which provides them with an incentive to negotiate the wage after the skills have been accumulated. Recognising this, workers tend to underinvest in skills, since they know they will not receive the full benefit of their investment. Investment in

skills relevant to the labour market and the different channels through which they can be acquired (from formal schooling to experience) make empirical investigation difficult. Further complexity is added by potential capital market distortions and the extensive role of governments in the financing and provision of training. But the growing availability of matched worker-firm data sets suggests some progress will soon be possible.

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skills is thus suboptimal from a social perspective and trade liberalisation may raise welfare through an additional channel if it increases the incentive to invest in skills.

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