Specialization in higher education and economic growth

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Abstract

This paper presents a new market failure in the decision on educational type in higher education. Individuals choose types of education with different degrees of specialization. Labor market transformation makes some individuals opt for a non-specialized education type that broadens the future career possibilities in an uncertain labor market. However, the growth rate in the economy is assumed to positively depend on the amount of specialized workers that get a job within their specialized field. Imposing a tax and transfer scheme in favor of specialized education types may correct for the market failure and Pareto improve the economy if the transfer attracts a sufficiently large amount of new students to a specialized education type and if their effect on the growth rate is substantial.

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1 Introduction

There is a widespread consensus that a highly educated population is positive for the economy and for society in general. High-educated workers face lower unemployment risk, earn higher wages, are presumably better informed and make wiser decisions than low-educated workers. Moreover, a high-skilled labor force may also foster economic growth through more productivity enhancing innovations and a better adoption of new technology; see Bartel and Lichtenberg (1988) for a review. The magnitude of this growth externality has been extensively studied by Denison (1984), Schultz (1981), Psacharopoulos (1973), Becker and Lewis (1992) and Barro (2001). Although the results in these studies are mixed, recent results seem to indicate that higher education is more important than what has been shown in earlier studies; see Gemmell (1997) for a review of the literature.

Despite the acknowledgement of the importance of higher education for economic growth, surprisingly little attention has been given to the impact of the distribution of higher education enrollment among different types of education, such as educations to become a lawyer, teacher or engineer. Higher education has often been treated as a homogenous good, although no one would think that all high-educated individuals have the same possibility of affecting the growth rate. Two exceptions where the type of education is highlighted are Murphy et al. (1991) and Zilibotti and Storesletten (2000). Both papers emphasize the importance of engineers as a growth-enhancing education and work type.[1]

This paper suggests another form of heterogeneity among different education directions, namely the degree of specialization. This may be of importance for the extent to which high-educated workers affect economic growth. The basic idea is simple. The transformation of the labor market makes the decision of type of education uncertain. This is due to the fact that occupa-

[1] Alstadsaeter et al. (2005) also distinguish among different education types, but their focus is not the effect on the growth rate, bur rather on the overall unemployment rate.

tions which are in high demand at the time of the education decision may be in less demand when the education is finished and the individuals enter the labor market, and vice versa. This may cause some individuals to opt for a broad education type, including different subjects, in order to insure against unemployment or having to take an unskilled job. The broader education may be designed to give a basic knowledge in several areas, thereby broadening the future career possibilities.

The theory of the division of labor stresses the importance of specialized workers for increased productivity and thus economic growth; see Lavezzi (2003) for a historical review. Hence, if growth increases all individuals' wages, there could be under-investment in specialized education types since individuals do not take into account the effect of their education decision on the growth rate. This problem might have been aggravated in the last decades, keeping in mind the increasing speed of globalization and its consequences for the magnitude of labor market transformation. I present some support for this hypotheses in the following section, together with a presentation of and support for the theory of division of labor.

In the model, individuals are heterogeneous in their preference for risk. They all face the same education decision, a specialized education direction followed by an uncertain labor market, or a broad direction which gives a safe payoff. If they choose the risky option, they have some exogenous probability of ending up in high-paid work which suits their specialized education type, or they are unlucky and get a regular work where their education investment is not productivity enhancing. The broad option gives a low but safe payoff of the education investment. Because of the heterogeneous preference for risk, some individuals will choose the risky alternative and some will opt for the certain one. The growth rate is assumed to affect all individuals equally by proportionally entering the wage function.[2] Moreover, since the

[2]This way of modelling is also used in Creedy and Francois (1990) and von Greiff (2007).

paper focuses on the importance of specialized workers, only individuals that choose a specialized education type *and* work in their specialized field affect the growth rate. The government can impose a proportional tax, which does not alter the education decisions due to its proportional nature. The tax finances a transfer, to which only the individuals who have opted for an uncertain education type that turns out to be unproductive are entitled. Thus, the government is able to alter the incentives to the different education directions. I assess in which cases this intervention is Pareto improving, which will depend on the efficiency of the transfer in attracting more risk willing students, and the magnitude of the positive effect of specialized workers *who get employed in their specialized fields* on the growth rate.

An analogue to the government's intervention is the portfolio theory and the trade-off between stocks and bonds. In this paper, the stocks are represented by specialized education types and the bonds by the broad education type. The stocks' payoff is more variable than that of the bonds, but their expected payoff is also higher.[3] By increasing the share of stocks in the portfolio, the government increases the total expected payoff and also makes more use of the externality effect from the amount of stocks in the portfolio. This is done by increasing the payoff of failing, which could be viewed as decreasing the variability of a specific stock. Hence, the transfer paid to failing specialists can be viewed as the government imposing an insurance system in order to benefit more from the growth externality.

The rest of the paper is organized as follows. In the next section, I present earlier literature on the two main components of the paper. First, I argue for the importance of the division of labor and its relation to the choice of educational type. Second, I present some facts suggesting that the speed of transformation of the labor market is substantial and may even be faster today than some decades ago. In Section 3, I present the model with and without government intervention. In Section 4, I assess the condition for

[3]See Brealey and Myers (1991) for an introduction to portfolio theory.

government intervention to be Pareto improving. Section 5 concludes.

2 Earlier literature

2.1 Division of labor and specialized education

The theory of division of labor and economic growth goes as far back as Adam Smith (1776) in his canonical *Wealth of Nations*. In short, it emphasizes the importance of specialized workers for increasing returns in the production process and thereby economic growth. In a thorough review of the theory in a historical perspective, Lavezzi (2001, p. 4)) states that according to Smith,

labor productivity ... essentially depends on the division of labor which: a) improves the *dexterity* of the worker; b) allows the worker to save the time necessary to switch among different activities; c) puts the worker in the condition of inventing machines and facilitates his job. In modern terms, we see how Smith had in mind the concepts of learning by doing, (point a)), set-up costs (point b)), and endogenous technological progress (point c)).

and in the following

...therefore technological advances ... can be considered as *consequences of an increased division of labor* among and within firms, since they proceed at a certain speed only when (i) some classes of men become exclusively engaged in producing machines, or (ii) in producing knowledge or (iii) when workers concentrate on a particular phase of the production process.

For another historical review of the theory, see Lavezzi (2003). Later on, the validity of these old thoughts has been acknowledged by prominent economists like Stigler (1951), Romer (1987) and Becker and Murphy (1992), which all focus on different factors that limit specialization, such as the stocks of physical and human capital, the costs of coordinating labor and transportation costs. To my knowledge, the link to educational choice has not yet been explored, however. The degree of specialization in the work force may naturally depend on more factors than the degree of specialization in workers' educations. Such things might be on-the-job-training, which could be focused on specialized skills, and individuals' skills developed in other ways than formal education. Nevertheless, it is hard to reject the highly plausible possibility that the degree of specialization in higher education has a significant impact on the degree of specialization of the labor force, as I assume in this paper.

2.2 Labor market transformation

If there were no labor market transformation, individuals could choose a specialized education type that they knew *ex ante* the education decision would result in a job adequate for the skills learnt during the education. However, this is usually not the case. Some labor market sectors decrease or even vanish, while others start up and yet another experiences a boom. The common view is that "globalization or technological change has increased the speed with which economies must adjust. The workforce must be reallocated between sectors, occupations or geographical regions in order to respond to changing patterns of demand." (Greenaway et al. 2000, p. 2).

This view, however, is partly questioned in the same paper. They find that the rate of sectoral transformation in the UK was higher in the 1970s and 1980s than during the 1950s and 1960s, but that it has then decreased to the same levels as in the postwar decades. Independent of the *change* in the speed of sectoral transformation, there is strong support for the prevalence of a substantial ongoing sectoral transformation. Moreover, many studies have found it to be an important factor behind unemployment rate fluctuations; see, for example, Lilien (1982), Loungani et al. (1990), Brainard and Cutler (1993) and Mills et al. (1995).

In this paper, I model the uncertainty of sectoral transformation as if individuals risk getting a low-paid job if they fail to get a job in their specialized field. Alternatively, there might be a risk for individuals of being unemployed, as suggested by the above evidence. For the purpose of this paper, it is not important to distinguish between whether individuals opt for a broad education to insure against a low-paid job or against unemployment.

In many countries, there are many possibilities among which to choose for a broad education type. For example, a closer look at the applicant catalogue for universities in Sweden reveals that there are indeed a great number of education types including several different subjects. Moreover, there are typically very few restrictions on how to combine different subjects into a degree. Therefore, it is common for a degree to include subjects from completely different disciplines.

3 The Model

Consider an economy populated with individuals who are only heterogeneous in their preference for risk. Their utility function exhibits constant relative risk aversion and is written

$$U(c) = \frac{c^{1-X}}{1-X} \tag{3.1}$$

where c is consumption, which is equal to the wage rate since labor supply is normalized to one for all individuals. A low and a high X indicate low and high relative risk aversion, respectively. Moreover, X is distributed with a density function $f(X)$ with support $[0,1)$[4] and the total mass of individuals

[4]The model can be generalized to include $X \geq 1$. However, my choice of the support of X is made for computational convenience without loss of generality.

is normalized to unity. All individuals choose between different types of education [5], resulting in different wage rates on the labor market There are $N \geq 2$ different education subjects and each of them constitutes a type of education. In addition, there is a broad education type where all N subjects are included. Hence, in total there are $N+1$ different education options, labelled $n, n = 1, 2, ..., N, N+1$. K of the N education types are known to be labor market sectors that demand labor when the individuals' educations are finished, where $1 \leq K < N$. However, the structural transformation of the labor market makes it impossible to know *ex ante* the education decision, which of these types it will be. Therefore, some individuals may want to choose the broad education type, that is $n = N + 1$, in order to insure against the possibility of not having chosen one of the right subjects. The reason is that if that happens, the individual's education has not increased her productivity in the labor market.

The exogenous probability that a chosen specialization will be demanded in the labor market is $\frac{K}{N} = p$ for all $n = 1, 2, ..., N$. If one of these types is chosen, $c = w(1+g)\overline{k}$ with probability p and $c = w(1+g)$ with probability $1-p$, where w is some common wage rate in the different occupations, g is the growth rate and $\overline{k} > 1$ is a productivity increase due to education. The broad education type $n = N+1$ results in a safe income $c = w(1+g)\underline{k}$, where $1 < \underline{k} < \overline{k}$. $\overline{k} > \underline{k}$ represents the different productivities of the education types. The safe income is higher than the income of the specialized education type if it turns out to be the wrong one, but lower than the specialized education type if this turns out to be the right one. Let V(S) and V(B) define the indirect utility function for the specialized and broad education type, respectively. In sum, choosing $n = 1, 2, ..., N$ gives the expected indirect utility

[5] Since the paper focuses on the composition of different types of education, the possibility of choosing no education at all is not an option. This is also the case in Alstadsaeter et al. (2005).

$$E(V(S)) = p\frac{\left(w(1+g)\overline{k}\right)^{1-X}}{1-X} + (1-p)\frac{(w(1+g))^{1-X}}{1-X} \tag{3.2}$$

Choosing $n = N + 1$ gives the expected utility

$$E(V(B)) = V(B)) = \frac{(w(1+g)\underline{k})^{1-X}}{1-X} \tag{3.3}$$

where the first equality follows from the fact that the broad education type gives a safe payoff. All individuals with $E(V(S)) > E(V(B))$ choose a specialized type of education[6] and those with $E(V(S)) < E(V(B))$ choose the broad education type. Let x represent the threshold level of risk aversion, that is the indifferent individual. The following equation implicitly defines x as a function of $\overline{k}$, $\underline{k}$ and p.

$$E(V(S)) = V(B)) \Longrightarrow p\overline{k}^{1-x} + 1 - p = \underline{k}^{1-x} \tag{3.4}$$

The following proposition then ensures an interior solution to the indifference equation.

[6]Since the specialized education types are equally likely to be the right choice and they give the same wage rate if they are the right choice, it is assumed that the individuals choosing a specialized type of education are evenly spread out among the different alternatives $n = 1, 2, ...N$.

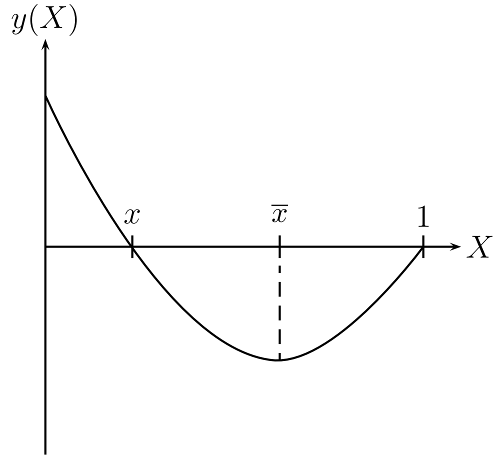
Proposition 1

Let $\frac{\underline{k}-1}{\overline{k}-1} < p < \frac{ln\underline{k}}{ln\overline{k}}$*. Then there exists* $x \in (0,1)$ *that solves equation (3.4). Furthermore, the solution is unique.*

Proof. Define the net utility of choosing a specialized education type $NU(X) = \frac{(w(1+g))^{1-X}}{1-X}(p(\overline{k}^{1-X} - 1) - \underline{k}^{1-X} + 1)$. NU for the risk neutral individual, $NU(0) = w(1+g)(p(\overline{k} - 1) - \underline{k} + 1) > 0$ by $\frac{\underline{k}-1}{\overline{k}-1} < p$. NU for the individual with highest risk aversion is $lim_{X \longrightarrow 1} NU(X) = pln\overline{k} - ln\underline{k} < 0$ by $p < \frac{ln\underline{k}}{ln\overline{k}}$. By continuity of $NU(X)$, there exists x such that $NU(x) = 0$. Second, define $y(X) = p(\overline{k}^{1-X} - 1) - \underline{k}^{1-X} + 1$. In any case, where $NU(x) = 0$, it also holds that $y(x) = 0$ since the first part of the net utility function, $\frac{(w(1+g))^{1-X}}{1-X}$, is positive for $\forall X \in [0,1)$. To show the uniqueness of the interior solution $NU(x) = 0$, it suffices to show that there is only one $x \in (0,1)$ such that $y(x) = 0$. First, y is continuous in X and the solution to $\frac{\partial y}{\partial X} = 0$, denoted $\overline{x}$, is unique. Second, $y(0) > 0$ by assumption and $lim_{X \longrightarrow 1} \frac{\partial y}{\partial X} = ln\underline{k} - pln\overline{k} > 0$ by assumption. That is, y approaches 0 from below. Hence, $y(\overline{x})$ must be negative. There then exists a unique interior solution $x \in (0,1)$ such that $y(x) = 0$.■

The intuition goes as follows. The assumptions in Proposition 1 ensure that $y(0)$ is positive and that y approaches 0 from below. Since the solution to the first-order condition of y is unique and y is continuous, the function y must have the form presented in figure 1 below. Finally, as argued above, the existence of an interior and unique solution to y implies that there also exists an interior and unique solution to NU.

Figure 1: The function $y(X)$



3.1 Comparative statics

Totally differentiating equation (3.4) yields

$$dx = \frac{(1-\overline{k}^{1-x})dp + (1-x)(\underline{k}^{-x}d\underline{k} - p\overline{k}^{-x}d\overline{k})}{\underline{k}^{1-x}ln\underline{k} - p\overline{k}^{1-x}ln\overline{k}} \tag{3.5}$$

The denominator of equation (3.5) is negative[7]. It is now possible to evaluate the comparative statics of x with respect to each of the variables. These results are summarized in Proposition 2.

[7] To see why, note that by Proposition 1, there exists a unique $x \in (0,1)$ and $y(0) > 0$. It then follows that $\frac{\partial y}{\partial X}\big|_{X=x} < 0$. This derivative evaluated at $X = x$ is simply the denominator of equation (3.5).

Proposition 2
$\frac{dx}{dp} > 0$, $\frac{dx}{d\overline{k}} > 0$ *and* $\frac{dx}{d\underline{k}} < 0$. *That is, the number of specialized individuals is increasing in* p *and* $\overline{k}$ *and decreasing in* $\underline{k}$.

Proof. Follows from equation (3.5) when evaluating the variables one at a time.■

x indicates the risk aversion of the individual who is indifferent between choosing the safe education type and one of the specialized education types. Recall that all individuals with $X \in [0, x]$ choose a specialized education type and those with $X \in (x, 1)$ choose the broad education type. The intuition behind Proposition 2 is presented in the following.

Note that an increase in p represents either an increase in K and/or a decrease in N. As p increases, the probability of having luck in a specialized education type increases, which makes a specialized education type more attractive. As a result, more individuals opt for a specialized education type and the indifferent individual is now an individual with a higher risk aversion.

As $\underline{k}$ increases, the productivity gap between the broad and the specialized educations decreases, that is $\overline{k} - \underline{k} \longrightarrow 0$ as $\underline{k} \longrightarrow \overline{k}$. In other words, it becomes more attractive to choose the broad education type. Hence, the indifferent individual is now an individual with a lower risk aversion.

As $\overline{k}$ increases, the productivity gap between the broad education type and the specialized education types increases. It becomes more attractive to choose a specialized education type. The indifferent individual is now one with a higher risk aversion.

3.2 The growth rate g

The economy's growth rate is decided by the number of individuals that choose a specialized education type which happens to be successful in the sense that it leads to a specialized occupation. All specialized individuals are assumed to be evenly spread out among the different specialized types of education $n = 1, 2, ..., N$, since the expected pay-off is equal regardless of which of the specialized education types one chooses. Hence, the number of successful matches will simply be a pth fraction of the total number of individuals in specialized education types, which is

$$M = M(x) = \int_0^x f(X)dX, M' > 0 \tag{3.6}$$

The growth rate can thus be characterized as

$$g = g\left(\widetilde{M}\right), g' > 0 \tag{3.7}$$

where $\widetilde{M} = pM$.

3.3 Government intervention

As has been shown above, the share of individuals choosing a specialized education type is not fixed. Rather, it is endogenous and depends on the incentives of the different education options. These incentives might be altered by government intervention, if the government would like to alter the mass of individuals taking a specialized education type. Since individuals do not take into account the effect of their education choice on the growth rate, the laissez-faire equilibrium growth rate could be below the socially optimal one. In the following, a tax and transfer scheme is introduced.

Let income be taxed by a proportional tax t used to finance a transfer $T >$

0 targeted to individuals that choose a specialized education type which turns out to be wrong, i.e. the individuals with lowest incomes. The deadweight loss of taxation is represented by a marginal cost of raising public funds $\lambda(T) \in [0,1]$, $\lambda' > 0$, such that $T(1-\lambda(T))$ is the actual transfer payed. This cost is introduced because of the non-distortive nature of taxation. In the absence of this cost, the government would optimally manipulate the growth rate in an unrealistic way by choosing a T so high that all individuals would choose a specialized education type. Even though this social optimum outcome is still possible, the introduction of the cost ensures the possibility of an interior social optimum. This is the only type of equilibrium considered in this paper. For the purpose of this paper, it is of no importance whether the marginal cost of raising public funds reduces the transfer or increases the tax. All that matters is to introduce an efficiency loss to sidestep the unrealistic optimum that all individuals choose specialized types of education. I choose to let the cost reduce the transfer for transparency of the results.

The new indifference condition, the analogue of equation (3.4), can now be written

$$p[w(1+g)(1-t)\overline{k}]^{1-x}+(1-p)[w(1+g)(1-t)+T(1-\lambda)]^{1-x} = [w(1+g)(1-t)\underline{k}]^{1-x} \tag{3.8}$$

where $w(1+g)(1-t)\overline{k} = A$ is the risky individual's income if she succeeds, $w(1+g)(1-t)+T(1-\lambda) = C$ is the income if she fails and $w(1+g)(1-t)\underline{k} = B$ is the income for the individuals with a broad education type. For an interior solution, $T(1-\lambda)$ must be such that $A > B > C$. Define

$$F = p[w(1+g)(1-t)\overline{k}]^{1-x} + (1-p)[w(1+g)(1-t)+T(1-\lambda)]^{1-x} - [w(1+g)(1-t)\underline{k}]^{1-x} \quad (3.9)$$

where F is LHS-RHS in equation (3.8). Differentiating equation (3.8) with respect to x and T and solving for $\frac{dx}{dT}$ yields

$$\frac{dx}{dT} = -\frac{F_T + F_t \frac{dt}{dT} + F_\lambda \frac{d\lambda}{dT}}{F_x + F_g \frac{dg}{dx}} \quad (3.10)$$

$F_x < 0$ since the net utility of choosing a specialized education type decreases with risk aversion. F_g and F_t have opposite signs. Assuming that an increase in the growth rate does not benefit the individuals with specialized education more than those with a broad education, that is $F_g \leq 0$, then ensures the denominator to be negative. $\frac{dt}{dT} > 0$ for obvious reasons. Thus, x increases in T as long as the transfer net of the marginal cost of raising public funds is increasing in T. This condition can be written $F_T + F_\lambda \frac{d\lambda}{dT} > 0 \Longrightarrow \frac{d\lambda}{dT} < \frac{1-\lambda}{T}$. This expression shows that there is an upper limit to how sensitive the marginal cost of raising public funds can be to increases in the transfer. Above this limit, the increase in the transfer is more than outweighed by the increase in the marginal cost of raising public funds. In that case, increasing the transfer will *decrease* x and hence, the number of specialized individuals.

4 Welfare

In this section, I assess under which circumstances government intervention is Pareto improving. I also discuss the Pareto efficient level of the transfer and the social optimum. Before this is done, it is necessary to say something about the framework for the assessment. Recall that *ex ante* the education, individuals only differ in their preference for risk. *Ex post* education, however, there are three types of workers: workers with a broad education type, workers with a specialized education type who choose a relevant specialization, and workers with a specialized education type who choose a non-relevant specialization. It is obvious that individuals choosing the broad education type *ex ante* and a specialized one *ex post* the policy change, that is the switchers, may end up worse off if they happen to have chosen the wrong specialization. The focus in this paper for the assessment of Pareto improvement, however, is not the individuals' realized utilities but their expected utilities *ex ante* the realization of which specialization turns out to be fruitful in the labor market.

4.1 Pareto improvement

Since fiscal redistribution favors individuals with specialized education types, assessing Pareto improvements comes down to ensuring that the individuals with the broad education type benefit from the introduction of the tax and transfer scheme presented above. This will be the case if the positive growth externality outweighs the negative effect of taxation. This result is formally presented in the following proposition. Note that the growth rate can be expressed as a function of the transfer, by combining equations (3.6), (3.7) and (3.9).

Proposition 3
Government intervention is Pareto improving if

$$\frac{dg}{dT}(1-t) \geq \frac{dt}{dT}(1+g) \tag{4.1}$$

that is, when the growth externality outweighs the negative effects of taxation.

Proof. The consumption for the individuals with broad education is $c = w(1+g(T))(1-t(T))$. Calculating $\frac{dc}{dT} \geq 0$ and rearranging yields equation (4.1).■

Equation (4.1) is very intuitive. The LHS is the positive effect of the transfer, that is, the increase in the growth rate. The RHS is the negative tax effect for the individuals. Obviously, the higher is the growth rate, the higher is the possibility of government intervention being Pareto improving. It could thus be interesting to disentangle the different effects of an increase in the transfer on the growth rate. As explained above, using equations (3.6), (3.7) and (3.9) yields g as a function of T. In particular, $g = g(\widetilde{M}(x(T)))$. Hence,

$$\frac{dg}{dT} = \frac{dg}{d\widetilde{M}}\frac{d\widetilde{M}}{dx}\frac{dx}{dT} = p\frac{dg}{d\widetilde{M}}\frac{dM}{dx}\frac{dx}{dT} \tag{4.2}$$

where the second equality comes from the fact that $\frac{d\widetilde{M}}{dx} = p\frac{dM}{dx}$. From equation (4.2), it is clear that the growth increase is higher 1) the higher is the probability that a specialized worker gets a good match in the labor market, 2) the higher is the effect of good matches on growth, 3) the larger is the number of students that switch from the broad education type to a specialized one for a given change in the cutoff value of risk aversion and 4) the larger the sensitivity of the cutoff value to the change in the transfer.

4.2 Pareto efficiency and social optimum

If equation (4.1) is fulfilled when introducing the tax and transfer system, that is evaluated at $T = 0$, it means that the individuals choosing the broad education type would benefit from an increase in the transfer. Consequently, they will be better off by increasing the transfer up to the point where equation (4.1) holds with equality, that is T is such that $\frac{dc}{dT} = 0$. At this point, the positive growth effect of the transfer exactly cancels the negative effect of taxation. Call this level of the transfer T_B^*. The optimal level of the transfer for the specialists will be $T_S^* > T_B^*$, however. The reason for this is that not only does the specialists benefit from the increase in the growth rate but they also get the direct effect of the transfer. The Pareto efficient allocations are thus $\forall T \in [T_B^*, T_S^*]$, where $T_B^* = 0$ if $\frac{dc}{dT}\big|_{T=0} \leq 0$ for the individuals choosing the broad education type and $T_S^* = 0$ if $\frac{dE(U(c))}{dT}\big|_{T=0} \leq 0$ for the specialized individuals. Naturally, the social optimum T^* will depend on the utility weights put on the different types of individuals, but is bounded by the optimal levels for the different types. Proposition 4 formalizes the results of this discussion.

Proposition 4
Let $\frac{dV(B)}{dT}\big|_{T=0} > 0$*, that is, the individuals choosing the broad education type benefit from the introduction of the transfer. Then* $T_B^* < T_S^*$*, the social optimum* $T^* \in [T_B^*, T_S^*]$ *and* $\forall T \in [T_B^*, T_S^*]$ *are Pareto efficient allocations.*

Proof. See the **Appendix** for the proof of $T_B^* < T_S^*$. $\frac{dV(B)}{dT} > 0$ at $T \in [0, T_B^*)$, $\frac{dV(B)}{dT} < 0$ at $T > T_B^*$, $\frac{dE(V(S)}{dT} > 0$ at $T \in [0, T_S^*)$ and $\frac{dE(V(S))}{dT} < 0$ at $T > T_S^*$. Hence, $\forall T \in [T_B^*, T_S^*]$ are Pareto efficient allocations and $T^* \in [T_B^*, T_S^*]$. ■

5 Conclusions

The paper has introduced a new market failure in the decision on enrollment in higher education. An uncertain labor market with a high speed of sectoral transformation may make individuals insure themselves against an uncertain labor market by choosing a broad education type. This may harm the economy, however, if specialized workers are an important factor behind innovations and other activities fostering economic growth. The government can overcome this problem by introducing a tax and transfer scheme working as an insurance for individuals who choose a specialized education type that turns out to be a waste. In this way, a specialized education type becomes more attractive and some individuals will switch from a broad to a specialized education type. I assess under which condition this intervention Pareto improves the economy. This will be the case as long as the switchers' effect on the growth rate is sufficiently large to compensate the individuals choosing the broad education type for their tax deduction.

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Appendix

T_B^* is the solution to $\frac{dV(B)}{dT} = 0$.

$$\frac{dV(B)}{dT} = (w\underline{k}(1+g)(1-t))^{-X} w\underline{k} \left(\frac{dg}{dT}(1-t) - \frac{dt}{dT}(1+g) \right) = 0 \tag{5.1}$$

T_S^* is the solution to $\frac{dE(V(S))}{dT} = 0$.

$$\frac{dE(V(S))}{dT} = p(w\overline{k}(1+g)(1-t))^{-X} w\overline{k} \left(\frac{dg}{dT}(1-t) - \frac{dt}{dT}(1+g) \right) +$$

$$(1-p)(w(1+g)(1-t))^{-X}w\left(\frac{dg}{dT}(1-t)-\frac{dt}{dT}(1+g)+1-\lambda-T\frac{d\lambda}{dT}\right) \quad (5.2)$$

Note that without the term $1-\lambda-T\frac{d\lambda}{dT}$ in equation (5.2), $T_B^* = T_S^*$. This term is positive and represents the additional positive effect of the transfer that the specialized workers enjoy, that is, the *direct* effect of the transfer. That implies that the parentheses must be negative which, in turn, implies that $T_B^* < T_S^*$.