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ABSTRACT

This paper explores the role of government policies in a situation where the wage gap between high-skilled and low-skilled workers is widening due to increasing foreign competition in the manufacturing of low-skilled intensive goods. A two-period, two-sector general equilibrium model of a small open economy is developed in which individuals choose whether to invest in skills or not. The government influences individual decision-making by redistribution of income or by subsidizing investment in skills. Both types of policies have complicated effects on income inequality and social welfare. The first policy discourages investment in skills while the latter, although successful in inducing more investment in skills, tends to be regressive by favoring those who acquire skills. Yet for a given income tax rate the Lorenz curves of the two different policies intersect. When the government maximizes social welfare education subsidies are useful only if there is a high degree of inequality aversion and financing the subsidy is not too distortive.

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1. Introduction

The enormous increase in world trade over the last decades, as documented for example by Krugman (1995), has contributed substantially to the overall rise in living standards in most countries. Yet, people and governments of many industrialized countries have recently blamed trade with low-cost countries for the increasing wage gap between high-skilled and low-skilled workers in their countries.[1] In the academic literature most authors agree that trade with low-cost countries is at least partially responsible for the rising gap. This view is shared by Rodrik (1997) who nicely summarizes the debate.[2] Many companies in developing countries have indeed become more competitive in the manufacturing of low-skilled intensive goods for a number of reasons, among them lower transportation costs and tariffs. This in turn leads to a reduction in output of low-skilled intensive goods and lowers overall demand for unskilled labor in industrialized countries.

Governments have responded to this political and economic challenge by proposing various remedies. In the USA, President Clinton has recently introduced education IRA's which allows parents to save on a tax-preferred basis for the education of their children. The idea behind this policy is to make education affordable which thereby mitigates the rising gap indirectly. By contrast, most European countries are troubled by high unemployment, in particular among low-skilled workers. Until recently, low-income earners and unemployed workers in Europe received benefit packages that are generous by U.S. standards. However, with increasing integration and high levels of taxation more and more people become unemployed while the costs of maintaining the welfare state seem to increase without end. Thus some European countries, like the Netherlands and Sweden, have scrapped or downsized their benefit packages. Other countries, like Germany, haven't done so although they are considering similar policies.

To the extent that increasing foreign competition is indeed at least partially responsible for the widening wage gap, several important policy questions arise. What is the 'best' way of dealing with income inequality in an open economy? Should governments use scarce

[1] Sachs and Shatz (1996) document the increasing wage gap in the USA.

[2] There exists now a huge literature on how important trade is in explaining the increasing wage gap. Borjas and Ramey (1995), Leamer (1996), Richardson (1995) and Wood (1995) find that trade has an important influence on wage inequality, while Bhagwati and Dehejia (1994) and Lawrence and Slaughter (1993) are more skeptical.

resources to encourage investment in education or to redistribute income in favor of those who remain unskilled? More specifically, how costly is redistribution of income when low-cost countries gain market share? How successful are education subsidies? Do education subsidies lead to more income inequality than an income redistribution scheme? These type of questions haven't been addressed in the literature.[3]

The present paper attempts to fill this gap by providing a framework that allows me to study these questions. To this end, I develop a simple two-sector, two-period general equilibrium model of a small open economy in which the skill distribution of the working population is endogenous and influenced by government policy. Individuals decide in the first period whether to invest in education or not. The education decision depends on the type of government policy and the degree of competition from abroad that prevail in the second period. Two different government policies are considered. First, the government may use all tax revenues from the labor income tax to pay a uniform lump sum subsidy to all workers (skilled and unskilled). This policy is equivalent to a linear income tax. The second option is to use tax revenues for subsidizing investment in education.

The reason for choosing these two policies is that they seem to have quite different consequences both from a distributional perspective and from the point of view of an individual who considers investment in education. A linear income tax tends to be progressive because of the uniform subsidy, thereby mitigating the increasing wage gap between low-skilled and high-skilled workers. Yet, at the same time the policy reduces the incentive to become a skilled worker in the first place. This in turn reduces the amount for redistribution because overall tax revenues are smaller when fewer workers invest in education. Increasing competition from abroad may lessen this, though, since a widening wage gap makes it more attractive to become a skilled worker. By contrast, when the government subsidizes investment in education, more people tend to become skilled workers. The downside of this policy seems to be that a regressive bias is built in because the existing tax money is used for those who in the end are better off anyway. Increasing integration has interesting effects here too.

[3]There is a growing interest in issues of income distribution and human capital accumulation in open economies, see for instance Deardorff (1997) and Ranjan (1998). An early treatment is Findlay and Kierzkowski (1983). Only Deardorff discusses government intervention. His focus is on the international repercussion effects of a factor tax which arise when the terms of trade are endogenous. By contrast, this paper deals with different types of redistribution policies and how these compare in terms of income inequality. For convenience, this question is analyzed in a small open economy.

A widening wage gap induces more people to invest in education, but this in turn reduces the per capita subsidy. An important objective of this paper is to shed more light on these trade offs. It will be shown that government policies have a non-trivial effect on the income distribution in an open economy. The initial conjecture that a redistribution scheme leads to less income inequality is not generally true.

The plan of the paper is as follows. After setting up the basic model up in section 2, the following section 3 analyzes changes in tax policy and the degree of foreign competition when the skill distribution is exogenous. This 'short-run' analysis is a building block for the analysis when skills are endogenous. Under quite weak assumptions it is shown that more foreign competition widens the wage gap, increases total income, while higher taxation of labor income reduces total income. An increase in foreign competition is modeled as a decline in the price of the import good which is the low-skilled intensive good. When preferences are quasi-linear the disincentive effect of taxation is larger, the stronger competition from abroad is. These outcomes are roughly consistent with the stylized facts mentioned above.

Section 4 focuses on two different types of government policies when the skill distribution is endogenous. Particular emphasis is given to the derivation of the number of people who invest in education and the level of GDP as a function of the price of the import good and the tax rate on labor income. In general, increasing foreign competition has a nontrivial effect on both variables. When deciding whether to invest or not to invest in education, an individual compares the utility of being a skilled and unskilled worker in the second period. The difference in utilities is a function of government policy, in particular the revenue available for redistribution purposes or education subsidies. The tax revenue itself is a function of how many people find it attractive to invest and the degree of foreign competition. An equilibrium is a fixed point in terms of the number of people who invest in skills.[4]

When the government redistributes incomes through a linear income tax with a uniform lump sum subsidy (Regime A), the comparative statics effects are 'intuitive' under some mild assumptions. Increasing foreign competition provides more incentives to invest in education and raises GDP. A tax increase has the opposite effect. By contrast, when

[4]This problem is technically similar to the problem in the 'opting-out' literature where individuals decide whether to attend a public or private school. See Epple and Romano (1996) and Glomm and Ravikumar (1998).

the government subsidizes investment in education (Regime B), comparative statics effects are often ambiguous even when preferences are restricted to be quasi-linear. A tax increase cannot only induce more workers to invest in education, but may also increase GDP. More foreign competition may or may not raise GDP. A sufficient condition for GDP to increase is that the unsubsidized cost of education is not too high relative to the difference in gross labor incomes of a skilled and an unskilled worker.

The results from section 4 are used in section 5 to compare the two policy regimes along various dimensions. Most importantly, for a given income tax rate I analyze which of the two regimes leads to a more equal distribution of incomes and how the comparison may change as foreign competition intensifies. The comparison in terms of income inequality is based on the concept of Lorenz dominance (see Lambert (1993) for details). At first glance it may seem obvious that the income redistribution scheme always Lorenz dominates a regime of education subsidies, simply because the former is 'progressive' while the latter is 'regressive'. This turns out not to be true. It is shown that the generalized Lorenz curves intersect when preferences are quasi-linear. This is partly due to the fact that labor income and GDP are higher under education subsidies.

In section 6 I endogenize policy and search numerically for policies that maximize social welfare. Social welfare is based on individual utilities which includes the disutility from labor supply and the opportunity costs of becoming skilled. The scope of the analysis is extended by considering also hybrid policies which combine elements of income redistribution and education subsidies. Several important insights emerge. For modest degrees of inequality aversion optimal policies under all regimes give about the same level of welfare. Yet, the policies look quite different. For instance, under regime the optimal policy makes use of an education tax rather than a subsidy. An education subsidy is useful when inequality aversion is high and the subsidy is financed in a way that does not distort labor supply incentives too much. Section 7 presents conclusions and directions for future research.

2. The Model

In this section I set up a simple two-period, two-sector model of a small open economy which is inhabited by a large number of individuals. For simplicity, it is assumed that the size of

the population is normalized to one. In the first period each individual decides whether to invest in education or not. If the investment is (not) undertaken, the individual becomes a skilled (unskilled) worker in the second period. No other decision is made in the first period. In the second period firms produce two goods using skilled and unskilled workers. Individuals consume, supply labor, and pay back education expenses. Their decisions are based on government policy which comprises a constant marginal tax rate on labor income, a uniform lump sum subsidy, and a subsidy for those who invest in education. In the remainder of this section I describe in more detail the maximization problem of firms and individuals, introduce the government budget, and define an equilibrium for the economy.

Producers

The small open economy produces two goods using a constant returns to scale technology in both sectors. Unskilled and skilled labor are the inputs in the production of good 1. Good 1 is an intermediate good and is used together with unskilled and skilled labor to produce good 2. The advantage of having a vertical production structure is that only one good is consumed domestically and relative output price effects are not propagated through the demand side. The production functions are

$$\begin{aligned} Q^1 &= f^1(L_u^1, L_s^1) \\ Q^2 &= f^2(Z, L_u^2, L_s^2), \end{aligned}$$

where L_u^i and L_s^i are the amounts of unskilled and skilled labor used in sector $i = 1, 2$, and Z is the amount of good 1 used in sector 2. Any difference between Z and domestic output of good 1, Q^1, is imported $M > 0$ (or exported if $M < 0$),

$$Q^1 + M = Z. \tag{1}$$

Good 2 is either consumed domestically C or exported. Let X denote exports, market clearing in sector 2 requires

$$C + X = Q^2. \tag{2}$$

Let the price of good 1 be denoted by p. Good 2 is the numeraire good whose price is

normalized to one. The prices of skilled and unskilled labor are denoted w_s and w_u. Firms maximize profits which are $pQ^1 - w_u L_u^1 - w_s L_s^1$ and $Q^2 - pZ - w_u L_u^2 - w_s L_s^2$ in sector 1 and 2, respectively. All markets are perfectly competitive. Both goods are freely traded and the prices are taken as given in the small open economy.

Consumers

Individuals live for two periods and must decide in the first period whether to invest in education or not. Each individual is forward looking and makes her decision on the basis of correctly anticipated policies in the second period. Investment in education involves two types of costs. First, there is a monetary expenditure which is the same for every individual that wishes to become a skilled worker. Second, there is a (non-monetary) opportunity cost.[5] Individuals differ in terms of their non-monetary opportunity cost which is modeled as a utility loss.[6] Each individual's preferences can be represented as follows

$$V_j = v(c_j, l_j) - \theta \cdot \delta_j \tag{3}$$

where $c_j, l_j, j = s, u$, are consumption and labor supplied in the second period of a skilled and unskilled worker respectively. θ is the type-specific preference parameter that indicates the (non-monetary) opportunity cost of obtaining an education and is continuously distributed on the interval $[\underline{\theta}, \overline{\theta}]$ with density $f(\theta)$. The indicator variable $\delta_j, j = s, u$, takes the value of one if an individual decides to invest in skills ($j = s$), and zero otherwise ($j = u$). The subutility function $v(c, l)$ is assumed to be continuous, increasing and concave in c, and decreasing and concave in l.

Investment in skills is costly. Let E be the unsubsidized price of education in terms of the numeraire good. Individuals may pay less than E if the government subsidizes investment in education. Let e be the subsidized price of education and $h = E - e$ the government subsidy

[5] The reason for having two types of costs is as follows. The uniform monetary cost is necessary to consider education subsidies, while the non-monetary, type-specific cost induces some, but not necessarily all individuals to become skilled. Having an interior solution allows me to study the number of skilled workers as a continuous function of various parameters.

[6] One way to interpret the opportunity cost is that it represents the value of leisure or 'fun' time when an individual is young. Rather than studying, a young individual may prefer doing sports, watching TV, etc. Individuals differ in their preferences for pursuing these type of activities.

per worker who invests in education. I assume that the good education is not produced domestically, but rather the economy imports the service (e.g., teachers) from abroad.[7]

Individuals finance investment in education by borrowing. I assume that individuals are not credit constrained and can borrow against future labor income at a zero interest rate. In the second period all individuals honor their obligation to pay back education expenses. The budget constraint of an individual is thus

$$c_j + \delta_j E = (1-t)w_j l_j + g + \delta_j h, \tag{4}$$

where t is a constant marginal tax rate on labor income, g is a uniform lump sum subsidy, and $g + \delta_j h$ is the sum of government transfers. In the second period each individual maximizes (3) subject to (4) given δ. In the first period individuals decide whether to invest in education or not by taking into account second period behavior.

The number and fraction of individuals who become skilled (unskilled) workers is n_s ($n_u = 1 - n_s$). Total consumption is $C = n_s c_s + (1 - n_s)c_u$, and aggregate supply of skilled and unskilled labor are $L_s = n_s l_s$ and $L_u = (1 - n_s)l_u$, respectively.

Government

The government imposes a labor income tax in the second period and redistributes revenues to individuals in form of a uniform lump sum subsidy or by subsidizing the investment in skills. Let $Y = w_s L_s + w_u L_u$ denote total labor income (which equals average income), the government budget constraint reads

$$tY = g + n_s h, \tag{5}$$

where either g or h is zero under the two policies considered below. Note that the total lump sum subsidy equals the per capita lump sum subsidy because population size is normalized to one.

[7] Alternatively, I could follow the approach taken by Findlay and Kierzkowski (1983) who assume that skilled labor is produced by using some input called capital. The results of section 3 go through under that approach, but the derivation of results with endogenous skills becomes quite messy.

As a final step, gross domestic product and the trade balance condition are introduced. GDP equals the sum of all outputs minus purchases of intermediate goods and expenditures for education,

$$\tilde{Y} \quad = \quad pQ^1 + Q^2 - pZ - n_s E \quad = \quad Y - n_s E. \tag{6}$$

Since education is an imported service, the trade balance condition reads

$$pM + n_s E = X \tag{7}$$

which states that total purchases from abroad, comprising good 1 and education, must equal the value of exports.

Equilibrium

For a given government policy vector and given world prices (t, g, h, p, E) an allocation of resources $(c_j, l_j, n_j, Z, L_j^1, L_j^2, Q^1, Q^2, M, X)_{j=s,u}$ and a factor price vector (w_s, w_u) form an equilibrium if

i) for given prices and government tax and transfer policies, each individual chooses optimally whether to invest in education or not, and given her skill-type she chooses optimally consumption and labor supply in the second period,

iii) all labor markets clear, i.e., $L_u^1 + L_u^2 = L_u = n_u l_u$ and $L_s^1 + L_s^2 = L_s = n_s l_s$

iv) all goods market clear (i.e., (1) and (2) hold)

v) trade is balanced (7)

vi) the government budget (5) is balanced

vii) firms maximize profits given prices.

Note that under the last condition perfect competition and constant returns to scale imply zero profits. The model can be solved as follows. Assuming nonspecialization, gross

wages are determined by the world market through trade. Due to constant returns to scale, relative prices fix only relative input demands. The equilibrium allocation is therefore determined by labor supply which is a function of government policy. The education decision and the amount of labor supplied depend on net wages and government transfers $g + \delta_j h$. Government revenues in turn are a function of the given gross wages and labor supply. Hence the government budget constraint and the labor supply functions jointly determine the total amounts of labor used. Given these values, the zero profit conditions in sectors 1 and 2 determine the input demands. The amount of imports M can be found from (1), while the value of exports X is determined by the trade balance condition. The market for good 2 then must clear by Walras' Law because all 'agents', including the foreign sector, satisfy their budget constraint.

3. Comparative statics when skills are exogenous

The model is solved in two steps. This section deals with the effects of two parameter changes for a given distribution of skills. This is equivalent to analyzing the second period of the model. Section 4 deals with the problem of an endogenous skill distribution and thus incorporates the first period of the model. The first of the two parameter changes considered in this section is the role of increasing foreign competition in the market for good 1. An increase in foreign competition is modeled as fall in price of good 1.[8] Secondly, I examine the role of increasing taxation, i.e., an increase in the marginal tax rate t. In both cases, the purpose is to find out how either of these changes affects total labor income. Note that gross wages are unaffected by tax policy in a small open economy.

I now turn to the second period problem and in particular the profit mazimizing input decisions. Let K^i be the unit cost function in sector i, then profit maximization implies

$$p = K^1(w_u, w_s) \tag{8}$$

$$1 = K^2(p, w_u, w_s) \tag{9}$$

when both goods are produced. For given terms of trade wages are determined by equation

[8] I follow here Borjas and Ramey (1995) who also do not explicitly model the reason for more foreign competition. Possible reasons are lower transportation costs, reduced tariffs, entry of firms in developing countries due to lower fixed costs, foreign subsidies etc.

(8) and (9). Comparative statics are easily derived. Differentiate the two previous equations one obtains

$$\frac{dw_u}{dp} = \frac{K^2_{w_s} + K^1_{w_s} K^2_p}{\Delta} \tag{10}$$

$$\frac{dw_s}{dp} = -\frac{K^2_{w_u} + K^1_{w_u} K^2_p}{\Delta} \tag{11}$$

where $K^2_p, K^i_{w_s}, K^i_{w_u}$ are the partial derivatives of the unit cost function in sector i with respect to factor prices and $\Delta = K^1_{w_u} K^2_{w_s} - K^1_{w_s} K^2_{w_u}$ is the determinant. The partial derivatives are positive and equal to the optimal input-output coefficients according to Shephard's Lemma. The signs of (8) and (9) then depend on the determinant. I assume that for any value of p sector 1 is low-skill intensive, that is $\Delta > 0$. It is then clear that a decrease in p, i.e., increasing foreign competition, lowers the wage of unskilled workers, while it increases the wage of skilled workers. Thus a fall in p widens the wage gap.

The consumer maximization problem in the second period is analyzed next. At this point individuals are either skilled or unskilled. If skilled, an individual needs to pay back education expenses. The maximization problem of an individual is then

$$\max_{c_j, l_j \geq 0} \quad v(c_j, l_j) \quad s.t. \quad c_j + \delta_j E \leq w^n_j l_j + g + \delta_j h, \tag{12}$$

where w^n_j is the net wage. When the budget constraint is binding and $c_j \geq 0$, the problem can be expressed as one of choosing labor supply by solving the budget constraint for c_j and inserting in $v(c_j, l_j)$. Assuming an interior solution, the first order condition for this problem is $v_c \cdot w^n_j + v_l = 0$ where $v_c > 0, v_l < 0$ are the partial derivatives of the utility function with respect to consumption and labor evaluated at (c_j, l_j).

It is convenient to introduce a variable which lumps together government transfers and education expenditures. In slight abuse of terminology, I define

$$I_j \equiv g + \delta_j(h - E) = g - \delta_j e$$

as "non-labor income." Using this notation, the solution to (12) defines an optimal labor supply function $l^*_j = l_j(w^n_j, I_j)$, an optimal consumption function $c^*_j = w^n_j l^*_j + I_j$, and the

indirect utility function in the second period $v_j^* = v(c_j^*, l_j^*)$, as functions of the net wage and non-labor income. These functions are assumed to have the following properties.

- *Assumption 1*: Optimal labor supply is nondecreasing in the net wage and nonincreasing in non-labor income.

This assumption implies that optimal consumption is increasing in the net wage. For certain purposes we will impose two additional assumptions.

- *Assumption 2:* Optimal consumption is nondecreasing in non-labor income.

- *Assumption 3*: The marginal utility of consumption does not increase as consumption and labor increase jointly, or formally, $v_c(c_1, l_1) \leq v_c(c_2, l_2)$ when $c_1 \geq c_2$ and $l_1 \geq l_2$.

Assumption 3 will be imposed in situations where $c_s \geq c_u$ and $l_s \geq l_u$. The assumption then implies that the marginal utility of consumption for a low-skilled worker is not less than the marginal utility of consumption for a high-skilled worker.

The above results and assumptions can be used to derive most of the effects of changes in p and t on total labor income, GDP, and the number of individuals who invest in skills. For some results it is necessary to assume a specific functional form for the utility function. The case of quasi-linear preferences yields interesting and often clear insights. In that case it is assumed that preferences take the form $v(c, l) = c - h(l)$, where the first and second order derivatives of $h(l)$ are assumed to be positive, $h_l > 0, h_{ll} > 0$.

It is now possible to derive the comparative statics effects with respect to p and t. Recall that total labor income is $Y = w_s L_s + w_u L_u$. With an exogenous skill distribution a change in Y equals the change in GDP. The following expression, which is derived in Appendix A.1, shows how total labor income changes with the price of the low-skilled intensive good

$$\frac{dY}{dp} = \frac{L_u \frac{dw_u}{dp}(1+\varepsilon_u) + L_s \frac{dw_s}{dp}(1+\varepsilon_s)}{1 - t\left(\alpha w_s \frac{\partial l_s^*}{\partial I_s} + (1-\alpha) w_u \frac{\partial l_u^*}{\partial I_u}\right)} \tag{13}$$

where $\varepsilon_s \geq 0$ and $\varepsilon_u \geq 0$ represent the price elasticities of uncompensated labor supply for skilled and unskilled workers, respectively. The parameter $\alpha \in [0,1]$ indicates how government revenues are split between skilled and unskilled workers.[9] The sign of (13) can be easily determined. The denominator is always positive regardless of the value of α when the marginal tax rate is positive and assumption 1 holds. The sign of the numerator is negative if we make the additional assumptions that the country imports good 1 and $\varepsilon_s \geq \varepsilon_u$ because

$$L_u \frac{dw_u}{dp}(1+\varepsilon_u) \quad + \quad L_s \frac{dw_s}{dp}(1+\varepsilon_s) \quad \leq \quad (1+\varepsilon_u)(Q^1 - Z) \quad < \quad 0.$$

Thus, for a given skill distribution more foreign competition increases total labor income.

Similarly, the effect of a tax increase on total labor income is

$$\frac{dY}{dt} \quad = \quad \frac{-w_s^2 \frac{\partial L_s}{\partial w_s^n} \quad - \quad w_u^2 \frac{\partial L_u}{\partial w_u^n} \quad + \quad Y\left[\alpha w_s \frac{\partial l_s^*}{\partial I_s} + (1-\alpha) w_u \frac{\partial l_u^*}{\partial I_u}\right]}{1 \quad - \quad \left[\alpha w_s \frac{\partial l_s^*}{\partial I_s} + (1-\alpha) w_u \frac{\partial l_u^*}{\partial I_u}\right]} \quad < \quad 0 \qquad (14)$$

which is negative under the assumptions on the labor supply function, regardless of the value of α. This result is quite intuitive because a tax increase reduces work incentives directly via a lower net wage and indirectly because higher tax revenues tend to reduce labor supply through higher non-labor income (Assumption 1).

An interesting question is whether the reduction in income due to higher taxation increases or decreases as the economy faces increasing foreign competition. In order to address this issue I need to evaluate the sign of $\frac{d^2Y}{dtdp}$. The sign is ambiguous in general, as can be seen by differentiating (14) with respect to p. The sign is unambiguous, however, when preferences take the particular quasi-linear form $v(c,l) = c - \frac{l^2}{2}$. In this case labor supply is a linear function of the net wage rate only and all income affects are absorbed in c. Thus

$$\frac{d^2Y}{dtdp} \quad = \quad - \quad \frac{2}{(1-t)}\left[L_s \frac{dw_s}{dp} + L_u \frac{dw_u}{dp}\right] \quad > \quad 0, \qquad (15)$$

[9] The reason for introducing the parameter α is as follows. In the second period, the distribution of skills is given and therefore the government can split revenues among skilled and unskilled workers as it wishes. The parameter α reflects the split. Since in the second period governments transfers are exogenous from an individual perspective, the value of α has no impact on comparative statics. When the skill distribution is endogenous (sections 4 and 5), transfers to skilled and unskilled workers are endogenously determined.

where the inequality sign follows from the fact that the term in brackets is negative, as was argued above. This result is intuitive in the sense that tax increases are 'more costly', the more intense foreign competition is.

Proposition 1 *Consider a small open economy with an exogenous skill distribution that imports good 1. Assume also that good 1 is low-skill intensive relative to good 2 ($\Delta > 0$).*

a) *More foreign competition (a lower price of good 1) increases the wage gap between skilled and unskilled workers.*

b) *A decline in p increases total labor income if $\varepsilon_s \geq \varepsilon_u \geq 0$.*

c) *Total labor income is reduced by an increase in the marginal income tax rate.*

d) *When preferences are quasi-linear (with quadratic disutility from labor), the disincentive effect of taxation is larger, the lower is the price of good 1.*

For the remainder I will continue to assume that the economy imports good 1 and sector 1 is low-skill intensive.

4. Government policies when the skill distribution is endogenous

I now turn to the case where the distribution of skills is endogenous rather than exogenous. This requires an analysis of the individual decision making in the first period. Individuals are forward looking and compare their second period utility levels with and without education. When an individual of type θ invests in education, her overall utility level is

$$V_s^* = v(c_s^*, l_s^*) - \theta \tag{16}$$

where optimal consumption and labor supply are defined above. On the other hand, when not investing in education, an individual obtains

$$V_u^* = v(c_u^*, l_u^*). \tag{17}$$

An individual becomes a skilled worker when $V_s^* \geq V_u^*$ and remains unskilled otherwise. When evaluating the difference in utility levels, each individual takes into account government policies. Optimal consumption and labor supply are functions of fiscal policy. I consider two different policy regimes. In the first, called Regime A, the government returns all tax revenues in form of a uniform lump sum subsidy. There is no subsidization of education ($h = 0$). The government budget constraint becomes

$$g^A = tY^A = t[n_s^A w_s l_s^A + (1 - n_s^A) w_u l_u^A]. \tag{18}$$

A skilled worker's non-labor income in the second period is $I_s^A = g^A - E$, while an unskilled worker receives $I_u^A = g^A$.[10]

The second regime B is one where the government subsidizes investment in education ($g = 0$). The government budget constraint reads

$$tY^B = n_s^B h^B \tag{19}$$

or alternatively,

$$t[w_s l_s^B + \frac{(1 - n_s^B)}{n_s^B} w_u l_u^B] \quad = \quad h^B \quad = \quad E - e^B$$

Non-labor income is now $I_s^B = -e^B$ for a skilled worker and $I_u^B = 0$ for an unskilled worker.

For each regime k, $k = A, B$, there exists a critical value of the type-specific parameter θ, called θ^k, which makes an individual indifferent between obtaining education and not. This critical value is found by equating (16) and (17)

$$\theta^k = v^k(c_s^k, l_s^k) - v^k(c_u^k, l_u^k). \tag{20}$$

The number and fraction of individuals who invest in skills under regime k, n_s^k, is related to the critical value as follows

[10] For notational simplicity, I omit the symbol * when referring to optimal choices. Instead, I use A and B to indicate optimal consumption and labor choices under the two regimes.

$$n_s^k = \begin{cases} 0 & \text{if } \theta^k < \underline{\theta} \\ \int_{\underline{\theta}}^{\theta^k} f(\theta)d\theta & \text{if } \underline{\theta} < \theta^k < \overline{\theta} \\ 1 & \text{if } \theta^k > \overline{\theta} \end{cases} \tag{21}$$

The equilibrium value of the type-specific parameter θ^k, and hence n_s^k, can now be found by simultaneously solving the first-order condition to (12), and equations (19), (21) and (22) under regime A, and equations (20)-(22) for regime B.

4.1 Regime A: Redistribution of Income

Under this regime government policy is equivalent to a linear income tax. Note that the right hand side of (20) depends on the lump sum subsidy g^A. The uniform lump sum subsidy itself is determined by the government budget constraint, as given by (18). Jointly these equations determine the number of individuals who invest in education. In Appendix A.2 it is shown that an interior solution is unique in terms of the number of individuals who invest in skills.

An interesting question now is how total labor income and GDP respond to changes in the terms of trade and the tax rate. As an intermediate step, I first analyze how these changes affect the critical value θ^A. Assuming $0 < n_s^A < 1$, total differentiation of the system of equations gives

$$\frac{d\theta^A}{dp} = \frac{(1-t)(1-t\frac{\partial Y^A}{\partial g^A})\left[v_{sc}^A l_s^A \frac{dw_s}{dp} - v_{uc}^A l_u^A \frac{dw_u}{dp}\right] + t(v_{sc}^A - v_{uc}^A)\frac{\partial Y^A}{\partial p}}{1 - t\left[\frac{\partial Y^A}{\partial g^A} + (v_{sc}^A - v_{uc}^A)\frac{\partial Y^A}{\partial n_s^A} f(\theta^A)\right]}, \tag{22}$$

where $\frac{\partial Y^A}{\partial p} < 0$ and $\frac{\partial Y^A}{\partial g^A} < 0$ are the partial effects of p and g^A on Y for a given skill distribution n_s^A, as derived in (13). For notational convenience, I abbreviate the marginal utility of consumption of a skilled worker by v_{sc}^A (as a shortcut for $v_c^A(c_s^A, l_s^A)$), and similarly for v_{uc}^A. The denominator is positive under assumptions 1-3. The numerator is negative when either the tax rate is close to zero or $v_{sc}^A - v_{uc}^A = 0$. Then a fall in p unambiguously raises the number of people who invest in skills.

The comparative statics result for a tax rate increase is

$$\frac{d\theta^A}{dt} = \frac{(1-t\frac{\partial Y^A}{\partial g^A})(v_{uc}^A w_u l_u^A - v_{sc}^A w_s l_s^A) + (v_{sc}^A - v_{uc}^A)(Y^A + t\frac{\partial Y^A}{\partial t})}{D}, \qquad (23)$$

where $D > 0$ is the same denominator as in (22). Assuming that the economy operates on an upward sloping part of the government revenue curve ($Y^A + t\frac{\partial Y^A}{\partial t} > 0$) the last product of terms in the numerator of (23) is nonpositive. However, the sign of $v_{uc}^A w_u l_u^A - v_{sc}^A w_s l_s^A$ is ambiguous. In the case of quasi-linear preferences, however, θ^A falls with the tax rate. The marginal utility of consumption is the same for skilled and unskilled workers and (23) reduces to $d\theta^A/dt = w_u l_u^A - w_s l_s^A < 0$. An increase in the tax rate redistributes income from the skilled to the unskilled and thus makes investment in skills less attractive.

The comparative statics results (22) and (23) are now used to analyze the effect of changes in p and θ on GDP,

$$\frac{d\tilde{Y}^A}{dp} = \frac{dY}{dp}|_{n_s^A \text{ given}} + (w_s l_s^A - E - w_u l_u^A)\frac{dn_s^A}{d\theta^A}\frac{d\theta^A}{dp} < 0. \qquad (24)$$

To see that (24) is negative, recall from Proposition 1 that total labor income decreases for any given skill distribution. This means the first term in (24) is negative. The second expression in (24) captures the indirect effect of changes in p on the number of individuals who invest in skills. The expression is negative if $\frac{dn_s^A}{d\theta^A}\frac{d\theta^A}{dp} < 0$ and the term in brackets is positive. The latter holds for positive tax rates because $c_s^A > c_u^A$ (by assumptions 1 and 2) is equivalent to

$$(1-t)\,(w_s l_s^A - w_u l_u^A) > E.$$

Using the same steps as above, it is straightforward to show that GDP is decreasing in the tax rate.

Proposition 2 *Suppose individuals decide in the first period whether to invest in education or not and the government uses income tax revenues to pay a uniform lump sum subsidy to all workers in the second period.*

a) *The number of people who invest in skills increases as foreign competition becomes more severe (price of good 1 declines) if either the income tax rate is sufficiently close to zero or preferences are quasilinear and the tax rate is positive.*

b) *The number of skilled individuals may decrease or increase when the marginal income tax rate goes up. A tax rate increase reduces the number of skilled workers if preferences are quasi-linear.*

c) *GDP increases as foreign competition intensifies when the skilled population becomes larger with lower prices of the import good and $t > 0$. GDP falls with an increase in the tax rate when preferences are quasi-linear.*

Proposition 2 is quite intuitive although it is interesting to note that the tax rate change is difficult to sign in general. The next section shows that the same restrictions on preferences are not sufficient to sign some comparative statics effects when the government subsidizes education.

4.2 Regime B: Education Subsidies

Regime B can be analyzed similarly to regime A. The main difference is that there is no uniform lump sum subsidy and the per capita education subsidy depends on the number of people who invest in skills. Equations (19)-(21) jointly with the condition for utility maximization determine the critical value and the number of individuals investing in skills simultaneously. In Appendix A.3 it is shown that an interior solution is unique in terms of n_s^B.

Starting from $0 < n_s^B < 1$, an increase in the tax rate changes the critical value θ^B as follows

$$\frac{d\theta^B}{dt} = \frac{v_{uc}^B w_u l_u^B - v_{sc}^B w_s l_s^B + \frac{v_{sc}^B}{n_s^B}(Y^B + t\frac{\partial Y^B}{\partial t})}{1 + v_{sc}^B t w_u l_u^B f(\theta^B)(n_s^B)^{-2}}, \tag{25}$$

where $\frac{\partial Y^B}{\partial t}$ is the derivative for a given skill distribution, as given in (14). The denominator is positive whenever the tax rate is positive. The sign of the numerator is ambiguous in general. For a sufficiently small tax rate or inelastic labor supply, however, the numerator is positive because it reduces to $v^B_{uc} w_u l^B_u + v^B_{sc}((n^B_s)^{-1} Y^B - w_s l^B_s) > 0$. The intuitive reason is that a tax increase may provide funds to subsidize education, thereby inducing more people to become a skilled worker. This holds when a tax increase generates more revenues either because the tax rate is low or labor supply is relatively inelastic.

A change in p also affects θ^B. The derivative is unambiguously negative

$$\frac{d\theta^B}{dp} = \frac{(1-t)[v^B_{sc} l^B_s \frac{dw_s}{dp} - v^B_{uc} l^B_u \frac{\partial w_u}{\partial p}] + t\frac{v^B_{sc}}{n^B_s}\frac{\partial Y^B}{\partial p}}{1 + v^B_{sc} t w_u l^B_u f(\theta^B)(n^B_s)^{-2}} < 0, \tag{26}$$

where $\frac{\partial Y^B}{\partial p}$ refers to the case with a given skill distribution. Since both the wage of skilled workers and total labor income fall as the price of good 1 increases, the critical value always declines as the price goes up. This means that more people invest in education when increasing foreign competition makes the wage differential larger.

Proposition 3 *Suppose the government uses tax revenues to subsidize the investment in education (while the uniform lump-sum subsidy is zero).*

a) *The number of skilled workers increases as foreign competition becomes more severe (price of good 1 declines), but may decrease or increase when the marginal income tax rate goes up. An income tax increase has a positive effect when the tax rate is sufficiently close to zero or labor supply is inelastic.*

b) *GDP increases as foreign competition intensifies if the differential in gross incomes between a skilled and unskilled worker exceeds the unsubsidized price of education, i.e.,*

$$w_s l^B_s - w_u l^B_u \geq E. \tag{27}$$

c) *When the tax rate increases, GDP falls if (27) holds and* $\frac{d\theta^B}{dt} < 0$, *or if (27) does not hold and* $\frac{d\theta^B}{dt} > 0$.

The proof of part b) and c) is similar to the poof used in section 4.1. The effect on GDP is ambiguous without further restrictions because condition (27) may not hold in regime B. The reason for this is that the individual price of education, e, now differs from E. In that case the inequality $c_s^B > c_u^B$ does not imply (27).

5. Redistribution of income or education subsidies?

While the previous section established a series of results about each policy regime separately, we are now in a position to compare the two regimes directly. This is done in two steps. In this section the focus is on the comparison in terms of income inequality for given terms of trade and a given income tax rate. In the next section government policy is endogenized and direct measures of welfare (which will include the disutility from work and getting skilled) rather than measures of income inequality are employed. The reason for looking at income inequality under exogenous policy is at least twofold. First, the public policy debate centers on the increasing wage gap and hence income inequality. Secondly, public policy may be more constrained in terms of how easily tax rates can be adjusted rather than how tax revenues are spent. This point is reflected in the assumption that the income tax rate is given, but the government may use revenues for either income redistribution or subsidies to education. The following Proposition, which is proved in Appendix A.4, establishes results concerning individual welfare and overall income levels.

Proposition 4 *For a positive income tax rate and given values of p and E, regime A (redistribution of income) can be compared to regime B (education subsidies):*

a) *A skilled worker under regime B has more non-labor income than under regime A. This statement is equivalent to $Y^A \leq \frac{Y^B}{n_s^B}$.*

b) *Skilled (unskilled) workers do not work less (more) under regime A compared to regime B, i.e., $l_s^A \geq l_s^B$ and $l_u^A \leq l_u^B$.*

c) *When preferences are quasi-linear more people invest in skills when the government subsidizes education than when it engages in redistribution of income ($n_s^A < n_s^B$).*

d) *Suppose preferences are quasi-linear. If a worker is skilled (unskilled) under both regimes she is better (worse) off under regime B, i.e.,* $v_s^A < v_s^B$ *and* $v_u^A > v_u^B$.

e) *When preferences are quasi-linear, total labor income and GDP are smaller under regime A, i.e.* $Y^A < Y^B$ *and* $\widetilde{Y}^A < \widetilde{Y}^B$

Part e) is quite interesting. Based on result c) it may appear obvious that total labor income is higher under education subsidies assuming an interior solution under at least one regime. Yet, this is not necessarily so because skilled workers work possibly less compared to regime A. Quasi-linear preferences guarantee that labor supply is identical under both regimes. This is sufficient to prove that not only total labor income but also GDP is higher under education subsidies. Note that education subsidies appear in a favorable light when focussing on income inequality because the utility loss from work and investment in skills is neglected.

Proposition 4 is now used to compare regimes in terms of income inequality. One way of doing the comparison is by applying the concept of Lorenz dominance under which the cumulative proportion of total income is plotted against the proportion of the population ordered by income (Lambert, 1993). Regime $A(B)$ dominates regime $B(A)$ if the Lorenz curve of $A(B)$ lies inside the one of $B(A)$. Lorenz dominance has strong welfare implications if the average incomes of the two regimes are the same. Then Lorenz dominance is equivalent to welfare dominance for any well behaved social welfare function where individual utilities are defined over income. Average incomes are not identical here, however, according to Proposition 4e). For distributions with different means Shorrocks Theorem (see Lambert 1993) can be utilized. The Theorem asserts that generalized Lorenz dominance is equivalent to welfare dominance. The graph of a generalized Lorenz curve plots the cumulative income (as opposed to the cumulative proportion) against the proportion of the population. The following result shows that generalized Lorenz curves intersect and hence neither regime dominates the other in terms of income inequality.

Proposition 5 *Suppose individual preferences are of the quasi-linear form, the marginal income tax rate is positive and under both regimes there is positive number of skilled and unskilled workers. Then the generalized Lorenz curves of regimes A and B intersect.*

Proposition 5, which is proved in the appendix, is quite powerful. While education subsidies lead to higher GDP, the generalized Lorenz curve under regime B does not lie completely inside[11]. Hence regime B does not dominate regime A. Given relative GDP levels, it is also clear that a redistribution regime cannot dominate a regime with education subsidies here. The ambiguity in Proposition 5 arises because of two opposing effecs. Higher GDP under regime B tends to favor the dominance of education subsidies. Yet the regressive nature of education subsidies means that unskilled workers must be worse off in terms of net income when labor supply is the same across regimes. *Figure 1* illustrates the result of Proposition 5. Lorenz curves have the simple piecewise linear shape because there are only two skill types. Note that the kink in the Lorenz curve of regime A must be to the right of the kink of regime A ($n_s^A < n_s^B$). Proposition 5 implies furthermore that under the standard Lorenz concept regime B cannot dominate regime A either although the converse may be true.[12]

6. Welfare maximizing policies

In this section I continue the comparison of regimes by looking at social welfare based on individual utilities which includes the distutility from work and opportunity cost of education. Including the latter is important because education subsidies tend to lead to too many skilled workers on efficiency grounds alone. A strong concern for inequality may call for education subsidies however. The scope of the analysis is extended by considering also hybrid policies which combine educations subsidies and redistribution of income.

To evaluate welfare, I use an isoelastic social welfare function which allows for parametric variation of inequality aversion (see Atkinson and Stiglitz, 1980). For $\nu \neq 1$ and $k = A, B$, social welfare W is defined as

[11] The assumption that there are both skilled and unskilled workers is important here because with only skilled or only unskilled workers there could be Lorenz dominance. I am grateful to an anonymous referee who pointed out this assumption.

[12] Under the standard Lorenz concept Lorenz curves are scaled to go from (0,0) to (1,1). Since regime B does not dominate in a generalized sense, scaling the Lorenz curve of regime B relatively more cannot lead to dominance of education subsidies under the standard Lorenz concept. In a former version of this paper I showed that regime A dominates regime B in the standard Lorenz sense if $c_s^A/\widetilde{Y}^A < c_s^B/\widetilde{Y}^B$. Note that this condition depends on all parameters of the model.

$$W(t,g,h) = \frac{1}{1-\nu}\int_{\underline{\theta}}^{\overline{\theta}}(V(c,l))^{1-\nu}f(\theta)d\theta$$

$$= \frac{1}{1-\nu}\left\{\int_{\underline{\theta}}^{\theta^k}(v_s(c_s,l_s)-\theta)^{1-\nu}f(\theta)d\theta + \int_{\theta^k}^{\overline{\theta}}(v_u(c_u,l_u))^{1-\nu}f(\theta)d\theta\right\}, \quad (28)$$

where the critical value θ^k is a function of government policy parameters. The parameter ν indicates the degree of inequality aversion. Higher values of ν reflect increasing concern for inequality. $\nu = 0$ is the case of an additive social welfare function. Optimal policies cannot be easily characterized analytically. I therefore use specific functional forms and numerical solution techniques to gain some insight.

- Preferences : $V_j(c,l) = c - \frac{l^2}{2} - \theta\delta_j$
- Distribution parameter: θ is uniformly distributed on the closed interval $[0,1]$
- Production functions: $Q^1 = L_u$ and $Q^2 = 2\ Z^{0.5}L_s^{0.5}$.

The assumption that preferences are quasi-linear has two advantages. First, as was shown above, certain 'intuitive' results hold under the assumption and closed-form solutions for θ can be derived under all regimes. This is helpful here because the general-equilibrium effects are complicated enough and therefore the interpretation of results becomes somewhat easier. Secondly, the particular utility function implies that the uncompensated price elasticity of labor supply is unity. This value is probably too high from an empirical point of view. Yet to the extent that we are also interested in the efficiency cost of taxation, it is better to over- rather than to underestimate the labor supply elasticity.

On the production side the simplification is to use only unskilled labor in sector 1 and no unskilled labor in sector 2. This assumption makes sector 1 low-skill intensive. The Cobb-Douglas production function in sector 2 generates the following gross wage structure

$$w_s = \frac{1}{p}, \quad w_u = p.$$

I assume $p < 1$. The wage ratio is then $w_s/w_u = 1/p^2$. Using the optimal labor supply function $l_j = (1-t)w_j$, the labor-income ratio of skilled and unskilled workers is $1/p^4$.

Without redistribution or education subsidies the wage and income gap is then as follows: For $p = 0.8$ (0.7) a high-skilled worker's wage is about 50%(100%) higher, and her labor income about 150%(200%) higher than that of a low-skilled worker.

The distributional assumption on θ implies the convenient property that the critical value θ^k is equal to the number of individuals who invest in education n_s^k (assuming an interior solution). Using the specific functional forms, it is straightforward to compute the solutions to the critical values under the two regimes[13]

$$\theta^A = \frac{(1-t)^2}{2}\left(\frac{1}{p^2} - p^2\right) - E$$

and

$$\theta^B = \frac{(\frac{1}{p^2} - p^2)(\frac{1-t^2}{2}) - E + \sqrt{[(\frac{1}{p^2} - p^2)(\frac{1-t^2}{2}) - E]^2 + 4t(1-t)p^2}}{2}.$$

Imposing uniformity on $f(\theta)$ together with (20) implies that (28) can be simplified to

$$W(t,g,h) = \frac{(v_s(c_s,l_s))^{2-\nu} + (v_u(c_u,l_u))^{1-\nu}[(2-\nu)(1-\theta^k) - v_u(c_u,l_u)]}{(1-\nu)(2-\nu)}$$

For the numerical simulations the following parameter values are used. The price of education is set at $E = 0.2$. The terms of trade reflected by p take values of 0.75 and 0.7. The value of p has to be low enough so that the small open economy imports good 1.[14] For the parameter of inequality version I use values of $0, 0.5, 1.5$ and 3. The results are summarized in the following.

(1) When the social welfare function is additive ($\nu = 0$) no government intervention is the best policy in all regimes (regimes A and B, hybrid policy). The intuition is that with quasi-linear preferences the marginal utility of consumption is constant and identical across skill types. Government intervention is harmful then because the labor income

[13]The critical value of θ under the hybrid regime can be found as function of t and g by solving the government budget constraint for h and then substituting in the utility function. The critical value differs from θ^B by substracting $4g$ under the square root.

[14]For the simplified model imports can be expressed as $M = Z - Q^1 = (1-t)p[\theta^k(1+p^{-4}) - 1]$.

tax and the education subsidy distort private incentives without any benefits. For the baseline scenario without government intervention and $p = 0.75$, almost 41% of the population is skilled and unskilled workers have an income share of about 34%.[15]

(2) For modest degrees of inequality aversion ($\nu = 0.5, \nu = 1.5$) the optimal policies under all regimes give about the same level of welfare. Yet, the optimal policies look quite different. When $p = 0.75$, for example, under regime A a small income tax (3 to 6%) and a small poll subsidy (g is between 0.03 to 0.05) are optimal, while under regime B the government should combine a small income subsidy (2 to 5%) with a moderate education *tax* (0.05 to 0.15). Yet, the optimal hybrid policy does not make use of the income tax rate, but uses a poll subsidy (0.02 to 0.03) and an education tax (0.05 to 0.09). The poll subsidy is a useful instrument because unlike the income tax it does not distort labor supply. The reason behind the education tax is that in this model inducing people to invest in education is itself distortive and not optimal unless it brings huge gains in equality. With modest inequality aversion there are some gains in social welfare if fewer people become skilled. In fact, the fraction of the population that becomes skilled drops to between 31% to 39% (with the lower values relating to $\nu = 1.5$).

(3) For low values of ν welfare levels under the optimal policy and no intervention are not far away. This is not the case when inequality aversion is high. This finding is intuitive because the gains from government intervention are small when inequality aversion is relatively low.

(4) For a relatively high degree of inequality aversion ($\nu = 3$) welfare levels and government policies differ much more across regimes. For $p = 0.75$, under regime A a massive income subsidy (40%) should be financed through a high poll tax ($g = -0.9$). Compared to nonintervention, this policy induces almost all individuals to invest in education. Such an outcome cannot be replicated under regime B because a high income subsidy is outside the feasible set of government policies.[16] A feasible policy that aims at in-

[15] In the U.S. the income share of the 60 percentile is 33.1% in 1985 according to the World Development Report 1997. The percentage of the population that had some tertiary education was 56% in 1980, but has increased to 81% in 1993.

[16] Under regime B it would have to financed by an education tax which is impossible if too few people become skilled.

ducing people to become skilled is to subsidy education financed through an income tax. However this policy is far less effective in providing incentives for investment in skills and hence welfare is lower. The optimal policy under regime B, by contrast, finances an income subsidy (5%) through an education tax (0.15). The optimal hybrid policy is in its effects similar to the one under regime A, though the policy calls for a substantial poll tax (0.5) and a high education subsidy (0.6). Welfare levels under regime A and the hybrid policy differ substantially from welfare under regime B.

(5) Lowering the price of good 1 induces more people to become skilled *ceteris paribus*. For modest degrees of inequality aversion ($\nu = 0.5, 1.5$) the lump sum subsidy increases from 0.02/0.03 to 0.05/0.07 while the education tax remains about constant at 0.05 and 0.1, respectively, as p falls. This is not the case for $\nu = 3$ where the lump sum tax and the education subsidy fall.

The numerical exercises point to several interesting conclusions. Education subsidies financed by an income tax are not a very powerful tool to improve social welfare unless inequality aversion is high. Then, however, financing the subsidy with a poll tax is crucial. If tax revenue comes mostly from a distortive labor tax, education subsidies do not only distort the skill decision making, but also the financing. While the model may be overly optimistic and simplistic in assuming that the entire population could become skilled, it is important to recognize the differential performance of the three policy regimes. In the U.S. policy makers and parents alike have been advocating that students attend college. The increasing and widespread college enrollment supports the idea that in principle a large part of the population can become skilled.

Of course, education subsidies may play an important role when individuals are credit constrained, as shown by Perotti (1993) and Fernandez and Rogerson (1995). The present paper underscores that education subsidies are useful only under specific circumstances. Future research should address the issue of credit constraints in an open economy framework with government intervention and endogenous skill formation.

7. Discussion

The main purpose of this paper is to analyze government intervention in an economy that

faces a widening wage gap between high-skilled and low-skilled workers as foreign competition intensifies. Two distinct government policies are considered, an income redistribution scheme under which tax revenues are uniformly distributed among all workers and a scheme of education subsidies. Beside providing a simple formal framework to analyze these type of policies, one important insight from this paper is that even these relatively simple policies have quite complicated effects on GDP, the number of individuals who become skilled workers, income inequality and social welfare. In particular, education subsidies do not lead to less income inequality. The intuitive reason for this is that the amount available for redistribution purposes or education subsidies depends in a non-linear way on the number of people who invest in skills, the tax rate, and the degree of competition from above. Because of these complicated effects, the paper has focused on understanding how relatively simple government policies affect key variables. When government policy is endogenous, education subsidies are important only if inequality aversion is quite high and financing the subsidy is not too distortive.

Understanding government policies in an open economy with an endogenous skill distribution is of great interest in another context. For instance, many cross-country studies have failed to identify a clear connection between the size of government and the level or growth rate of GDP. Slemrod (1995) provides an excellent survey on this issue and argues persuasively that the type of government spending matters considerably when analyzing systematic links between government variables and measures of well-being. This point is confirmed here. The present paper adds to the explanation. The differential performance of low-tax and high-tax countries may be rationalized within an open economy model in which foreign competition in low-skilled intensive goods increases over time. Higher tax rates may have a positive impact on GDP when the revenue is used for education subsidies. Yet this is not always the case.

This paper can be seen also as complementary to the increasing literature on public finance in open economies. Over the last decade or so many public finance economists have focused their attention on the incidence and optimality of taxes when factor markets become more integrated. This has been of particular interest in Europe, but also among NAFTA countries, and among the states of the United States. One standard model is built on the assumption that capital becomes more and more mobile across countries or regions, while

labor is rather less mobile or even assumed to be immobile. Increasing mobility of capital has important consequences for tax policy because a higher elasticity of capital relative to labor requires lower tax rates on capital on efficiency grounds. This, however, has at least partly undesirable distributional consequences. The debate on trade and wage inequality is very similar because factor rewards widen as a result of increasing integration. It is therefore not only factor market integration that may lead to increasing inequality, but also increasing integraton of goods markets. This insight is not new to trade economists, but maybe less so to public finance economists. Trade economists, however, have not focused much on the implications for government policies, in particular when skills are endogenously determined.

The model in this paper is based on several assumptions that should be relaxed in future research. The assumption that individuals are not credit constrained is crucial. Relaxing this assumption is possible. For example, assume that individuals cannot borrow against future labor income. Instead individuals differ in their exogenous first-period endowment. For some individuals the endowment may be too small to pay for education expenses. Introducing such a modification is likely to generate additional complexities. Yet at the same time government policies, in particular education subsidies, may prove to be very important. A further extension in the same context is to endogenize the first-period endowment by assuming that each individual inherits some wealth from their altruistic parents. This extension is particulary interesting because it would not only explicitly introduce dynamics in the model, but would allow us also to understand the dynamics of income mobility in a dynamic open economy context.[17]

[17] An interesting contribution in a closed economy context is Chiu (1998).

Appendix

A1. Comparative statics for given skill distribution

A change in total labor income can be written as follows

$$dY = L_s \frac{\partial w_s}{\partial p} dp + w_s \left[\frac{\partial L_s}{\partial w_s^n} \frac{\partial w_s^n}{\partial p} dp + \frac{\partial L_s}{\partial I_s} dI_s \right] + L_u dp + w_u \left[\frac{\partial L_u}{\partial w_u^n} \frac{\partial w_u^n}{\partial p} dp + \frac{\partial L_u}{\partial I_u} dI_u \right].$$

For a given tax rate it follows from the government budget constraint

$$tdY = n_s dI_s + (1 - n_s) dI_u,$$

where I used the fact that $tY = g + n_s h = n_s I_s + (1 - n_s) I_u$. I assume that each skilled worker receives the share $\frac{\alpha}{n_s}$ of the change in government revenue, and each unskilled worker gets $\frac{1-\alpha}{1-n_s}$, where $\alpha \in [0, 1]$, so that $n_s dI_s = \alpha t dY$ (and analogously for unskilled workers). Then, substituting for dI_s and dI_u in the first equation, the comparative static effect of p on Y can be derived. A similar procedure can be used to analyze a tax change. Results are given in (13) and (14).

A.2 Regime A: Uniqueness of n_s^A

The number of individuals who invest in skills is unique when an interior solution exists. All individuals with $\theta < \theta^A$ invest in education and all individuals with $\theta > \theta^A$ remain unskilled. To prove uniqueness, assume for the moment that $\theta^A \in (0, 1)$ and consider equation (20). Both sides of the equation are functions of θ^A. The RHS is linked to θ^A via the government budget constraint (18) and the definition of n_s^A, as given in (21). There exists a unique interior value for θ^A if the RHS of (20) is nonincreasing in θ^A since the LHS is monotonically increasing. Differentiate the RHS of (20) which gives

$$\frac{d(v^A(c_s^A, l_s^A) - v^A(c_u^A, l_u^A))}{d\theta^A} = \left(v_{sc}^A \frac{dc_s^A}{dI^A} - v_{uc}^A \frac{dc_u^A}{dI^A} \right) \frac{dI^A}{dg^A} \frac{dg^A}{dn_s^A} \frac{dn_s^A}{d\theta^A}. \tag{29}$$

Using the envelope theorem and $\frac{dI^A}{dg^A} = 1$, it follows $\frac{dc_s^A}{dI^A} = \frac{dc_u^A}{dI^A} = 1$. Furthermore, $\frac{dg^A}{dn_s^A} > 0$ is positive which can be derived by totally differentiating the government budget constraint (18). Equation (21) shows that $\frac{dn_s^A}{d\theta^A} > 0$ when $f(\theta)$ is continuous. Thus there exists a unique

interior number of people investing in skills if it can be shown that $v_{sc}^A - v_{uc}^A \leq 0$. The final step therefore is to check that skilled workers have a higher marginal utility of consumption than low skilled workers. Note that $l_s^A \geq l_u^A$ holds by assumption 1 and the fact $I_s^A < I_u^A$. This implies that consumption of a high-skilled worker must exceed consumption of a low-skilled worker because otherwise nobody would have made the investment in skills. Thus $c_s^A > c_u^A$. Then Assumption 3 is sufficient to prove the claim. The monotonicity of all above derivatives implies that there can never exist more than one solution.

A.3 Regime B: Uniqueness of n_s^B

The uniqueness of n_s^B can be proved as in Appendix A.2. Differentiate the right hand side of (20), taking into account (20) and (22), gives

$$\frac{d(v^B(c_s^B, l_s^B) - v^B(c_u^B, l_u^B))}{d\theta^B} = -v_{sc}^B \frac{dc_s^B}{dI_s^B} \frac{de^B}{dn_s^B} \frac{dn_s^B}{d\theta^B},$$

where use was made of the fact that an increase in the price of education lowers nonlabor income by the same amount. It is easy to see now that $\frac{dc_s^B}{dI_s^B}$ and $\frac{dn_s^B}{d\theta^B}$ are positive. Differentiate the government budget constraint to find $\frac{de^B}{dn_s^B} > 0$.

A.4 Proof of Proposition 4

Proof of result a) by contradiction. Assume that the inequality does not hold, i.e. $Y^A > \frac{Y^B}{n_s^B}$ (called the claim now), so that at least $Y^A \geq Y^B$. The claim is equivalent to $I_s^A = g^A - E > -e^B = I_s^B$ (follows from the government budget constraints (18) and (19)), or by using the definitions of total labor income

$$w_u \left[(1 - n_s^A) l_u^A - \frac{(1 - n_s^B)}{n_s^B} l_u^B \right] > w_s (l_s^B - n_s^A l_s^A). \tag{30}$$

For (30) to hold, $l_s^A > l_s^B$ and/or $n_s^A > n_s^B$ is necessary since $l_u^A \leq l_u^B$. Under Assumption 1, however, skilled labor supply is higher under regime A if and only if $g^A - E < -e^B$. This contradicts the claim.

So, it must be true that $l_s^A \leq l_s^B$ if the claim is to hold. This in turn means for $Y^A > Y^B$ to be true, n_s^A must be larger than n_s^B. When there are more skilled workers under regime A, the left hand side of (30) is negative. However, $l_s^A \leq l_s^B$ implies also that the right hand side

of (30) is positive, a contraction to the initial claim. Thus it must be true that $Y^A \leq \frac{Y^B}{n_s^B}$ and $g^A - E \leq -e^B$.

Result a) implies $l_s^A \geq l_s^B$, which proves b). It is now possible to analyze under which regime the number of individuals with skills is higher (statement c). Suppose that $n_s^A > n_s^B$ or $\theta^A > \theta^B$. By (20), this in turn requires

$$v^A(c_s^A, l_s^A) - v^B(c_s^B, l_s^B) > v^A(c_u^A, l_u^A) - v^B(c_u^B, l_u^B).$$

This condition cannot hold. To see this, note that under quasi-linear preferences the RHS is positive because $l_u^A = l_u^B$ and $c_u^A > c_u^B$ if optimal consumption is nondecreasing in nonlabor income. The left-hand side is positive only if $g^A - E > -e^B$, a contradiction to a). Hence, $n_s^A < n_s^B$.

If a worker is unskilled under both regimes she is better off under regime A because $l_u^A = l_u^B$ and $I_u^A > I_u^B$ imply $c_u^A > c_u^B$. The same logic can be used to prove that a worker who is skilled under both regimes is better off under regime B.

Statement e) is easily proved when preferences are quasi-linear because $l_j^A = l_j^B, j = s, u$ together with $n_s^A < n_s^B$ implies $Y^A < Y^B$. In addition, for quasi-linear preferences $\tilde{Y}^A < \tilde{Y}^B$ holds. GDP is higher under regime B when $E < w_s l_s - w_u l_u$ because labor supply does not change across regimes when income effects are absorbed in consumption. The last condition is implied by the fact that $c_s^A > c_u^A$ which proves the claim.

A.5 Proof of Proposition 5

a) Consider the Lorenz curves in *figure 1.* A necessary condition for the Lorenz dominance of regime B is that under regime B the slope of the first segment of the Lorenz curve is larger than under regime A. The slope of the first segment is equal to cumulative income of unskilled workers relative to their population share. Regime B Lorenz dominates regime A if

$$\frac{(1-n_s^B)((1-t)w_u l_u^B + g^B)}{(1-n_s^B)} > \frac{(1-n_s^A)((1-t)w_u l_u^A + g^A)}{(1-n_s^A)}.$$

When preferences are quasi-linear $l_u^A = l_u^B$. Since $g^A > g^B = 0$ for positive tax rates, the slope under regime A must be higher.

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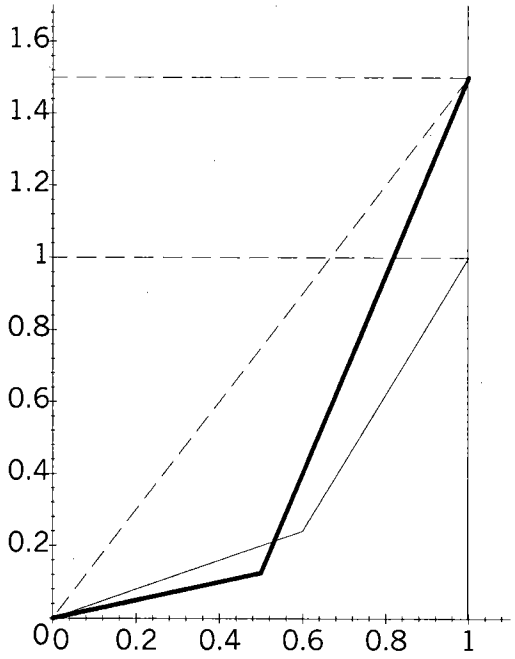
Figure 1

cumulative income



% of population

Figure 1: Lorenz curves intersect

Thin Line: Regime A

Bold Line: Regime B