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Education, Redistribution, and the Threat of Brain Drain
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ABSTRACT

This paper analyzes the relationship between brain drain, human capital accumulation and individual net incomes in the presence of a redistributional tax policy, credit market constraints, administrative costs of tax collection, and lack of government commitment. We characterize how decreasing migration costs for skilled workers affect the time-consistent policies of a government that wants to shift resources from skilled to unskilled workers. In our main result we show that a decline in migration costs is Pareto improving when migration costs are high, but have ambiguous effects when these costs are low. Moreover, mobility costs and human capital accumulation are positively correlated.

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"Does it matter if clever people leave in such numbers? For the world as a whole, it makes sense for the cleverest to exercise their skills where they earn the greatest reward. But what holds for the world may not hold for individual countries that lose large swathes of their educated middle class....To the loss of productivity potential, add the fiscal losses from migration. Taxpayers in developing countries have paid to educate many of those who leave... And emigration leaves behind fewer workers to pay the cost of looking after the old."

"On the other hand, emigration may bring other benefits to the sending country. The possibility of leaving and the higher income to be earned abroad may encourage more people to go into higher education. As not everyone will leave, the result will be a bigger pool of skills than would otherwise be the case." The Economist (2002, p. 30)

1 Motivation

The integration of world markets is a continuous process and changing in nature. At the beginning, international efforts aimed at tearing down the barriers to trade. In recent years, the focus has shifted from the free movement of goods to that of production factors. World-wide capital markets have been substantially liberalized, and international labor migration has been becoming an important issue. The growing integration of labor markets is partly based on institutional changes. The European Union, for instance, abolished all legal barriers to the movement of individuals in its jurisdiction and created a common labor market. Moreover, some previously rather 'closed' countries, like Germany, have opened their borders for skilled workers. Maybe more important, these political developments are accompanied and supported by technological progress. New information systems enable an Indian computer expert to search for a job in the United States from her home town. Since low transportation and communication costs reduce the expenses necessary to keep in touch with relatives and friends in the country of origin, the psychological barriers to emigration diminish too. All in all, the costs of international mobility have significantly declined over the last decades.

Nevertheless, there are still substantial hurdles to the movement of labor. Many countries are rather selective when they set their immigration criteria. Legal entry is often restricted to skilled workers. The educated are also those who can take advantage of the new technologies necessary to participate in the international labor market. For this reason mainly high-skilled workers can use the opportunity to substitute their jobs at home for better-paid ones abroad.[1]

The emigration of human capital concerns many opponents of globalization, as the first part of the above quote from the Economist is alluding to. The threat of brain drain puts pressure on governments to adjust their economic policy to the benefit of skilled workers, for example, by lowering the effective tax burden for high-income earners. The ensuing erosion of tax revenues restricts government interventions twofold. First, it limits redistribution toward those who cannot benefit from the new opportunities. Thus, society becomes more polarized, and social tensions may rise. Second, it constraints a govern-

[1] Becker et al. (2003), for instance, provide evidence for the rising mobility of well-educated individuals within Europe. They show that the graduates' share of the Italian emigrants quadrupled between 1990 and 1998. Between 3% and 5% of the annual graduates left Italy in this period. Carrington and Detragiache (1998, 1999) analyze extensive data on brain drain from developing to industrialized countries. For instance, 26% of the Ghanaians with tertiary education live abroad compared to only 0.7% and 0.1% of those with secondary and primary education, respectively. An overview of recent migration trends is also given in OECD (2003) and Wildasin (2000).

ment's ability to publicly fund accumulation of human capital. This support might be necessary to overcome market failures, such as insufficient access to credit markets, which limits a poor household's ability to receive higher education without public support.[2] All in all, many opponents of globalization fear that wealth will be increasingly concentrated in the hands of a declining number of people.

By contrast, proponents of globalization tell a different story, as the second part of the quote from the Economist suggests. International wage differentials for skilled workers provide strong incentives to invest in skills. To the extent that such differentials are driven by taxes, they also lead to desirable policy changes. Edwards and de Rugy (2002) point out that competition for human capital has intensified because international migration of skilled workers is increasingly motivated by tax differentials. In their view society benefits from higher mobility for the very reason that it curbs taxes and government spendings. Declining revenues force governments to reduce high administrative costs associated with the income tax and social security system, which in industrialized countries such as Canada and Great Britain amount to 7% and 5% of revenue collected, respectively (Vaillancourt, 1989, Sandford et al., 1989).[3]

Moreover, globalization softens the well-known hold-up problem caused by a redistributive government. Since governments are unable to commit credibly to a future tax policy, they implement policies that are optimal at the current point in time rather than stick to strategies that were optimal in the past. The resulting time-consistent policy tends to overtax the returns on human capital as an individual's investment in education is sunk once her labor income is subject to taxation (see, for instance, Boadway, Marceau and Marchand, 1996). Anticipating the burdens imposed by future taxation, households underinvest in human capital. Government intervention is therefore seen as the cause and not the solution to poverty and increasing polarization.

In the current paper we analyze the above arguments in favor and against globaliza-

[2] The returns to education investments are substantial - about 12% in Latin America and the Caribbean and still more than 8% in OECD countries for investments in higher education (see Psacharopoulos, 1994) - and can be seen as an indicator for underinvestment in human capital. The imperfect access to credit markets is emphasized in World Bank (1999, p. 52): "If credit markets for human resource investments are imperfect - as indeed they seem to be almost everywhere - households, particularly poor households, may not be able to finance investments in education despite high expected rates of return. Their lack of access to credit reflects information problems. Would-be lenders cannot properly assess the returns to investing in human capital, nor can such capital be collateralized".

[3] The problems and costs of tax collection are even more severe in developing countries. Acharya (1985), for instance, estimates that only 53.3% of India's taxable income was actually reported for tax purposes.

tion in the form of international migration of skilled workers.[4] While some fear that redistributive policies become impossible in a globalized world, others argue that world-wide liberalization helps to overcome the drawbacks associated with such policies. Since both sides rest their arguments on redistributive interventions, we focus on a 'left' government who wants to shift resources from skilled to unskilled workers. We study how declining migration costs of skilled workers affect the policy of such a government, how they shape the available incomes of skilled and unskilled workers, and how they influence human capital accumulation. The fall in migration costs may be the result of technological progress, as described above, or the result of political changes such as in the European Union. We also analyze how our conclusion depends on the degree of government efficiency, that is, the size of administrative costs associated with public interventions.

To this end, we capture the following stylized facts relating to the debate - credit constraints, administrative costs of tax collection and the government's lack of commitment - in a simple multi-stage model with internationally mobile skilled labor. We consider a small open economy which faces the threat of brain drain. The government controls an education subsidy, a transfer payment to unskilled worker, and a tax rate on skilled workers. In our main result we show that starting from a closed economy declining migration costs first improve the consumption of both skilled and unskilled workers, then worsen the consumption opportunities of all households, and finally benefit mobile skilled workers at the expense of the unskilled labor force.

This non-monotonic relationship between migration costs and individual welfare reflects two opposing forces at work. On the one hand, lower mobility costs reduce taxes on skilled workers and thus revenues available for redistribution. On the other hand, it also leads to cuts in administrative costs and in excessive education subsidies, which are necessary to sustain the incentives for private investment in education in anticipation of future high taxes. When mobility costs are high, the second effect dominates the first one, and more resources are available for redistribution. Unskilled workers gain from globalization through rising transfers, contrary to the claims of globalization opponents. However, if migration costs fall below a critical level - and thus are sufficiently low - the optimistic result is reversed. Even skilled workers suffer from rising mobility because lower taxes on their income are more than offset by the decline in the education subsidy. This result is in contrast to what globalization optimists expect. Perhaps worse, the size of the skilled labor force falls when migration costs decline precisely because the education subsidy falls.

As a consequence of the opposing effects of globalization, 'moderate' globalization is

[4] Other arguments in favor of skilled migration, but not considered here further, are remittances and possible increases in pay for remaining workers. See the Economist (2002) for further discussion.

optimal from the perspective of a redistributive government. The precise level of the 'optimal' migration costs depends on several factors, of which we discuss two in more detail. The poorer the country, as measured by the international wage differential for skilled workers, the less a 'left' government is in favor of globalization. More surprisingly, both countries with very efficient and very inefficient public sectors might embrace openness more than countries with medium administration costs.

Our paper extends and qualifies two strands of the literature. First, our work relates to recent contributions emphasizing positive effects of enhanced mobility. For instance, Beine, Docquier and Rapoport (2001), Mountford (1997), Stark, Helmenstein and Prskawetz (1997, 1998) and Vidal (1998) all argue that open borders make private investments in education more attractive. In their analyses, the gain from the positive incentive effect can dominate the negative effect from brain drain and, thus, increase human capital at home. Similar to these articles, we also claim that the opportunity of emigration can be beneficial for the source country, albeit for very different reasons. Unlike our paper, this literature does not consider taxes and subsidies.

The second strand of literature related to our paper deals with commitment problems and redistribution in the context of labor income taxation and human capital formation.[5] Andersson and Konrad (2000) compare a closed economy with a two-country world where migration costs of skilled workers are zero. In their analysis, globalization tends to increase welfare and might even lead to an efficient solution, since perfect mobility curbs excessive taxation of high incomes and thus softens the hold-up problem. This conclusion is qualified in Andersson and Konrad (2003). Tax competition of two Leviathan governments reduces the hold-up problem, but governments and the individuals might be worse off in the open economy because governments attempt to prevent education in the former case. Our paper also shows possible problems of globalization, but it follows a very different route. We stress the role of credit market constraints and administrative costs absent in Andersson and Konrad (2000, 2003), and characterize individual welfare as a continuous and non-monotonic function of migration costs.

The remainder of the paper is organized as follows: The next section presents the basic framework and some preliminary results. Section 3 characterizes the optimal tax and education policy of a redistributive government. In section 4 we analyze how the incomes of skilled and unskilled workers are affected by declining migration costs. The role of international wage differentials and administrative costs are explored as well. The final section concludes with a discussion of policy implications.

[5] The lack of commitment is also analyzed in other contexts. Boadway and Keen (1998) and Kehoe (1989) among others consider this problem in the case of capital income taxation.

2 The Model

In this section we develop a simple model of human capital accumulation, international migration, and government intervention. Particular attention is given to the size of migration costs, which are meant to capture the degree of globalization. Our approach incorporates four fundamental features, namely limited individual access to credit markets, administrative costs of collecting taxes, the government's inability to commit to future policies, and the threat of brain drain.

More specifically, a continuum of individuals lives in a small open economy and must make sequential decisions on education and migration. Individuals differ in their exogenous endowment and may be credit constrained when the need to finance education arises. The government intervenes by subsidizing education and, after education decisions are made, by taxing skilled workers and granting transfers to unskilled workers. The sequence of decisions therefore is (1) government implements education subsidy, (2) households decide on education, (3) government chooses tax and transfer levels, (4) skilled people decide on migration, and (5) all individuals supply inelastically one unit of labor and consume their income and their wealth.[6] The ordering of stages (2) and (3) generates a potential hold-up problem, which the government can mitigate by providing education subsidies in the first stage.

For the reasons mentioned in the introduction, we assume that the government pursues a redistributive objective by maximizing the net labor income of an unskilled worker (which is equivalent to maximizing the transfer to an unskilled worker). This objective function allows us to deal in a simple way with a centerpiece of the dispute over globalization, namely the relationship between globalization, redistribution and human capital accumulation.

2.1 Households

Individuals maximize the amount available for consumption z, which depends on gross wages, taxes, transfers, education subsidies, school costs, migration costs, and initial wealth. We explain each of these factors in turn.

In stage 2 individuals decide whether to attend school to become a skilled worker in stage 5. Without education a person is an unskilled worker in stage 5 with wage w_L.

[6] The increasing responsiveness of the migration choices of the high skilled to tax differentials is stressed, for instance, in Edwards and de Rugy (2002). Like Andersson and Konrad (2003, 2002), we take up this point by assuming that individuals decide on migration after the government set taxes and transfers.

Her skilled counterpart earns wage w_H when not migrating, and receives wage $\overline{w}$ (net of foreign taxes) in case of emigration gross of migration costs m. We assume $\overline{w} \geq w_H > w_L$, which reflects differential wages across countries and sets the stage for 'brain drain' to occur. We allow only skilled workers to emigrate. The possibility of low-skilled migration is briefly discussed in section 5.

Exogenous wealth y, which is portable in case of migration, is uniformly distributed on the support $[0, 1]$. Reflecting the presence of credit market constraints, we assume that an individual can invest in education only if her endowment y plus government subsidy s exceeds the costs of education c, that is,

$$y \geq c - s. \tag{1}$$

We assume $1 > c > 0$, so that in the absence of government intervention some but not all individuals are credit constrained.

In stage 5 an individual who does not emigrate is subject to tax T if she is skilled and receives transfer b if she is unskilled. Thus an individual's consumption z is

$$z = y + \begin{cases} \overline{w} - m + s - c & \text{if worker invests in skills and emigrates} \\ w_H - T + s - c & \text{if worker invests in skills and stays home} \\ w_L + b & \text{if worker remains unskilled.} \end{cases} \tag{2}$$

2.2 Government

The government has three instruments, namely the tax on income of skilled workers T, the transfer to unskilled workers b, and a uniform education subsidy s.[7] We assume that the education subsidy must be nonnegative. Collecting taxes on labor income is costly for the government. Apart from the basic administrative work involved in handling tax files, additional costs arise since people may try to hide their true income or bribe tax clerks. A household's attempt to evade or avoid payments are the more attractive, the higher taxes are. Consequently, the tax administration's expenses to discourage fraud and corruption increase in the assessed individual tax payment.[8] This feature is incorporated in our model by distinguishing between the tax T, which is the amount paid by the household, and the 'net' tax t, which remains for the government after the administrative costs of enforcing the tax T are deducted:[9]

$$t = f(T). \tag{3}$$

[7] The uniformity assumption is discussed below.

[8] Alternatively, we could assume that labor supply is endogenous and taxation creates a deadweight loss. The marginal loss is increasing in the tax rate.

[9] A similar notion is applied in Perotti (1993) and Bearse, Glomm and Janeba (2000).

The function $f(T)$ is assumed to fulfill the following properties for $T \geq 0$:

$$(i) \quad f(0) = 0 \quad (ii) \quad \partial f(0)/\partial T = 1 \quad (iii) \quad \partial^2 f/\partial T^2 < 0 \quad (iv) \quad \exists T : \partial f/\partial T = 0.$$

Property (i) is straightforward. According to property (ii), administrative costs are negligible for very small taxes. Moreover, properties (i), (ii) and (iii) together imply that $f(T) < T$ for all $T > 0$. The strict concavity of net tax t in individual payment T expressed by (iii) is equivalent to strictly convex administrative costs in T. Finally, (iv) restricts the maximum net tax, denoted by $\widetilde{t}$, which the government can obtain from a household. The corresponding tax payment by households is $\widetilde{T} = f^{-1}(\widetilde{t})$. The properties (i) to (iv) together imply a Laffer-type revenue function.

We assume that administrative costs occur only if the government enforces payments from households, but not when making transfers to households. Education subsidies and transfers to unskilled workers do not involve any enforcement expenses. Introducing such costs would reinforce their importance, but would also make the model less tractable without providing additional insights.

We can now state the government's budget constraint

$$sE + b\,(1 - E) = tH, \tag{4}$$

where E and H denote the total number of skilled individuals and the number of skilled workers not migrating, respectively. Expenditures for subsidies sE and transfers to unskilled workers have to be covered by the net tax payments from non-migrating skilled workers.

We solve for the time-consistent outcome, and characterize the equilibrium as a function of the migration costs parameter, the international wage differential for skilled workers, and the degree of government inefficiency in collecting taxes. When the government chooses tax T and transfer b in the third stage, it implements the policy which is optimal at that point in time, given the decisions in the previous stages. In stages 1 and 3 the government takes the subsequent responses of all individuals into account. Likewise, forward-looking individuals anticipate future optimal policies and act accordingly.

2.3 Some Preliminary Results

Before we solve explicitly for the equilibrium, we can already derive some preliminary insights that hold throughout. The outcome of the migration decision in the fourth stage is straightforward. A skilled worker compares her consumption level in her home region with her outside option. Since all other decisions are already made, only net wages and

migration costs are important at that point in time. She stays in her country of birth if and only if the *migration constraint*

$$w_H - T \geq \overline{w} - m \tag{5}$$

is fulfilled. This condition requires that the mobility costs m are higher than the international net income differential. Because wealth is assumed to be portable, condition (5) is independent of y and thus

$$H = \begin{cases} E & \text{if} \quad T \leq w_H + m - \overline{w} \\ 0 & \text{if} \quad T > w_H + m - \overline{w}. \end{cases} \tag{6}$$

Migration is an all-or-nothing decision. While this feature is unrealistic, it is sufficient for our purposes, namely to examine how government policy and human capital accumulation are affected by the threat of brain drain.

The second insight comes from establishing a condition for investment in education to take place. Individuals *want* to attend school if and only if it leads to a (non-strictly) higher consumption level, that is, if and only if the *incentive constraint*

$$\max\{\overline{w} - m, w_H - T\} + s - c \geq w_L + b \tag{7}$$

holds, where the left side of (7) is net income of a skilled worker, and the right side represents net income of an unskilled individual. Each individual faces the same incentive constraint, so that either all households want to invest in human capital or none.[10] Even if (7) holds, only those whose initial wealth exceeds $c - s$ can overcome the credit constraint (1) and *can* become a skilled person. Since the number of households for whom the credit constraint is not binding is $E = \int_{c-s}^{1} dy = 1 - (c - s)$, the aggregate outcome of the education decision in the second stage is given by

$$E = \begin{cases} 0 & \text{if} \quad (7) \text{ is } \textit{not} \text{ fulfilled} \\ 1 - (c - s) & \text{if} \quad (7) \text{ is fulfilled.} \end{cases} \tag{8}$$

The next insight follows from imposing reasonable restrictions on education costs relative to administrative costs and gross wages. In particular, we consider only the plausible case in which the government is not able to finance higher education for every

[10] The incentive constraint of wealthy individuals and thus the potential hold-up problem might be softened if the government used 'wealth-tested' subsidies and transfers as instruments. But even then, the incentive constraint would still exist, as long as the government revenue is constrained. A downside of conditioning education subsidies on wealth is that they increase administrative and compliance costs, as pointed out by the World Bank (1999, p. 52f).

individual. In addition, we assume that gross income gains of education exceed the costs of education. Formally, we have

Assumption 1 a) $\widetilde{t} < c$ b) $w_H - w_L - c > \widetilde{T} - \widetilde{t}$.

Part a) implies that not all individuals can become skilled since the maximum net tax - and hence the maximum education subsidy - falls short of schooling costs. The individuals with the lowest initial wealth ($y = 0$) end up as unskilled workers. Part b) means that education is socially desirable in the absence of credit constraints because $\widetilde{T} - \widetilde{t} > 0$ and therefore the skilled wage exceeds the unskilled wage plus schooling costs. Moreover, the social benefit from education exceeds the administrative costs per taxpayer at the maximum net tax. Without this feature no individual would become skilled, as will be argued in section 4.

Assumption 1 has another important implication. For all policies (s, b, T) which fulfill incentive constraint (7) and budget constraint (4), the domestic net wage of the skilled workers, $w_H - T$, is strictly higher than the net wage of an unskilled worker, $w_L + b$. In other words, the government is unable to equalize net wages by means of transfers to the unskilled even if educated people do not avoid domestic taxation through emigration. The reason is easy to see. If net labor income of the skilled and unskilled workers were identical, no individual would have an incentive to invest parts of her initial wealth in education. People would only become skilled if the school costs were completely funded by the government. Such a subsidy, however, is not feasible by assumption.

With our second assumption we restrict the parameter range for the migration costs as follows:

Assumption 2 $m \in \left[\overline{w} - w_H, \overline{w} - w_H + \widetilde{T}\right]$.

Migration constraint (5) shows that for all m in the interior of the interval $[\overline{w} - w_H, \overline{w} - w_H + \widetilde{T}]$ the government can set a strictly positive tax without driving skilled workers out of the country, but the tax falls short of the maximum tax $\widetilde{T}$. Only at the upper end of the interval, that is $m = \overline{w} - w_H + \widetilde{T}$, the possibility of brain drain does not restrict tax policy at all, and $\widetilde{T}$ can be implemented. Essentially the latter case mimics the case of closed borders. At the other extreme of the parameter range, where $m = \overline{w} - w_H$, any taxation of labor income of skilled workers is incompatible with no migration. Thus the lower end of the interval stands for 'total' openness. Considering values of m outside the interval does not add any further insights.

3 Redistribution and Education

In this section we characterize the optimal policy of a redistributive government and pay particular attention to its relationship to the migration costs. The government maximizes net labor income of an unskilled worker, $V = w_L + b$, which after using the government budget constraint (4), can be rewritten as

$$V = w_L + b = w_L + \frac{tH - sE}{1 - E}. \tag{9}$$

Maximizing welfare V is identical to maximizing the transfer to an unskilled household b. The endogenous variables s, b, t, T, E and H are solved for by means of backward induction. Note that stage 5 is trivial because individuals supply one unit of labor inelastically and consume all income and wealth.

3.1 The Threat of Brain Drain and Tax Policy

Taking the migration behavior (5) into account, the government chooses tax T to maximize (9) in the third stage. At that point the number of skilled people E and the subsidy s are given as results of past decisions. Government revenue tH is the only remaining endogenous variable in the objective function (9) since the other variables jointly determine total education expenses sE and the number of transfer recipients $(1 - E)$. The transfer to an unskilled worker increases in tH.

The government faces two limits when maximizing these revenues. First, administrative costs restrict the 'net' tax t to be at most $\widetilde{t}$. Second, the threat of brain drain constrains the maximum payment from educated workers to be equal to $w_H + m - \overline{w}$, which is the tax equalizing net income at home and abroad. The size of the migration costs determines which of these upper bounds is binding. If the 'price' of international mobility m equals the difference between foreign net wage $\overline{w}$ and domestic gross wage w_H (i.e., $m = \overline{w} - w_H$), no tax can be enforced from skilled workers and $T = 0$ is optimal. For migration costs $m \in \left(\overline{w} - w_H, \overline{w} - w_H + \widetilde{T}\right)$, strictly positive payments in the amount of $w_H + m - \overline{w}$ from skilled workers can be collected, but the government is still constrained by the threat of migration. Only for very high costs, $m = \overline{w} - w_H + \widetilde{T}$, the government is able to collect $\widetilde{T}$ without driving skilled workers out of the country. We illustrate the tax policy in figure 1 and summarize it in

Proposition 1 *Optimal Tax Policy.*
The optimal tax on skilled workers in stage 3 is given by

$$T^*(m) = w_H + m - \overline{w}, \quad \textit{where} \quad T^*(\overline{w} - w_H) = 0 \quad \textit{and} \quad T^*(\overline{w} - w_H + \widetilde{T}) = \widetilde{T}. \tag{10}$$

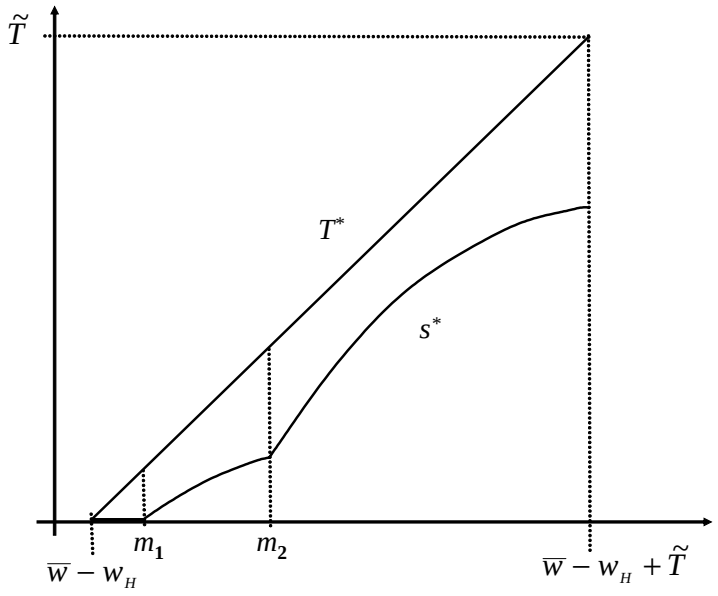

Figure 1: Optimal Tax and Subsidy

The optimal tax linearly increases in the parameter m, that is $\partial T^*/\partial m = 1$, a property we will use later. Since the government implements the maximum tax consistent with no migration, we can rewrite (6), the number of skilled workers staying in their home country, and obtain

$$H = E. \tag{11}$$

Although migration does not occur in equilibrium, the threat of brain drain in itself shapes the tax policy in the third stage.

3.2 Education Decision and Subsidy

We now turn to the analysis of the education subsidy and the households' education decision itself. When the government chooses the subsidy level, it anticipates the behavioral responses in all subsequent stages, in particular the induced investment in skills and future tax policy. Similarly, a household's education choice is not only based on the public subsidy, but each person also takes expected taxes and transfers into account. Individual decisions result from the credit constraint (1), the migration constraint (5), and the incentive constraint (7). The interaction of these constraints gives rise to three distinct cases, depending on the size of the migration costs, where the intervals $[\overline{w} - w_H, m_1]$, $(m_1, m_2]$

and $\left(m_2, \overline{w} - w_H + \widetilde{T}\right]$ represent low, intermediate and high migration costs, respectively. The optimal subsidy in these intervals and the number of skilled workers are stated in Proposition 2 and illustrated in figure 1.

Proposition 2 *Optimal Education Decision and Subsidy.*
(i) The optimal education subsidy is

$$s^*(m) = \begin{cases} 0 & \text{if} \quad m \in [\overline{w} - w_H, m_1] \\ s^o = c - \sqrt{c - t^*} > 0 & \text{if} \quad m \in (m_1, m_2] \\ s^{\min} = \frac{t^* - c\Omega}{1-\Omega} > s^o & \text{if} \quad m \in \left(m_2, \overline{w} - w_H + \widetilde{T}\right], \end{cases} \tag{12}$$

where $\Omega = w_H - w_L - c - (T^* - t^*)$ *and* $t^* = f(T^*(m))$. *The optimal subsidy* s^* *is a continuous function in* m. *It is constant for low migration costs and strictly increasing in* m *for intermediate and high migration costs.*
(ii) The number of skilled workers $E(m) = 1 - c + s^*(m) \in [1 - c, 1)$ *increases in* m.

We provide a formal proof in the appendix and discuss in the following the economic intuition. First, note that from the perspective of a redistributive government education subsidies are an investment into the national tax base. But this investment pays only if the 'return', i.e., the tax on the labor income of skilled workers, is sufficiently high. The education subsidy equals zero in the case of *low migration costs* ($m \leq m_1$) and thus a low tax T^*. The government simply uses all revenues to transfer them to unskilled workers.

The optimal subsidy becomes strictly positive in the case of *intermediate migration costs* ($m_1 < m < m_2$). On the one hand, the optimal tax T^* is now sufficiently high so that a strictly positive education subsidy is a beneficial investment for the government. On the other hand, the tax is still sufficiently low so that the net income of a skilled worker exceeds the net income of an unskilled worker. In other words, the incentive constraint is fulfilled, and each individual wants to invest in human capital. In this case, an education subsidy only serves as a device to overcome the individual credit constraint. The subsidy that maximizes objective (9), called s^o, is characterized by the first-order condition

$$\frac{dV}{ds} = -\frac{E}{1-E} + \frac{t^* - s}{(1-E)^2} = 0, \tag{13}$$

where we make use of $t^* = f(T^*(m))$ and $E = H = 1 - (c - s)$ (cf. (3), (8), (9), (10) and (11)). A larger education subsidy ties up government resources not available for redistribution. This direct spending effect is reflected in the first term of (13), which is negative. In the opposite direction works the second effect, which we term the indirect

'social composition effect'. Supporting investment in education reduces the number of unskilled workers who receive transfers, while at the same time it boosts the number of skilled workers subject to taxation. The compositional change enables larger transfers if the education subsidy s falls short of the expected net tax t^* (see second term of (13)). Moreover, the 'social composition effect' gains weight *ceteris paribus* if the net tax rises in response to higher migration costs. A higher future payment t^* makes it more attractive to promote schooling, and the optimal subsidy s^o increases in m.

For low and intermediate levels of m, the migration constraint is binding, but the incentive constraint is not. The situation changes when the migration costs exceed the critical value m_2, which is the case of *high migration costs.* Private investment in education is unprofitable unless a 'suboptimally' high education subsidy is granted in the first stage because high migration cost lead to heavy tax burdens and a low net wage $w_H - T_H$. Now, the education subsidy does not aim at 'optimally' overcoming the credit constraint, but its purpose is to ensure that individuals *want* to attend school. The government sets s such that the incentive constraint (7) is just fulfilled. The implemented subsidy s^{min}, which is the minimum subsidy necessary for the incentive constraint to hold, is above the level s^o. It serves as a second-best tool to compensate for the government's inability to commit to a lower tax in stage 3. The subsidy is larger, the higher the tax on skilled workers. Consequently, the necessary support s^{min} is positively related to the mobility costs.

Since the subsidy (weakly) increases in the migration costs over the whole domain of m, the number of people who can afford to attend school and become skilled also goes up. But the optimal subsidy is never sufficient to cover total school costs so that some individuals always remain unskilled, i.e., $E < 1$ holds.

4 The Welfare Effects of Globalization and Government Efficiency

We are now in a position to analyze the impact of globalization, i.e., a decrease in migration costs, on the incomes and consumption of skilled and unskilled workers. The next section shows that unskilled workers can gain and skilled workers can lose from globalization. Moreover, there exists a common level of migration costs which is locally 'optimal' for both income groups. Section 4.2 further explores how this 'optimal' openness and the net incomes depend on government efficiency and the wage abroad.

4.1 Redistribution and Migration Costs

The equilibrium policy yields an inverse u-shaped relationship between the net income of unskilled workers on the one hand and migration costs on the other hand. Moreover, the relation between the net wage of skilled workers minus private education costs and mobility costs are $\backsim$-shaped. We explain these results step by step, and illustrate them in figure 2 (for convenience, the net incomes adjusted for private education spending *minus* the constant w_L are drawn in figure 2).

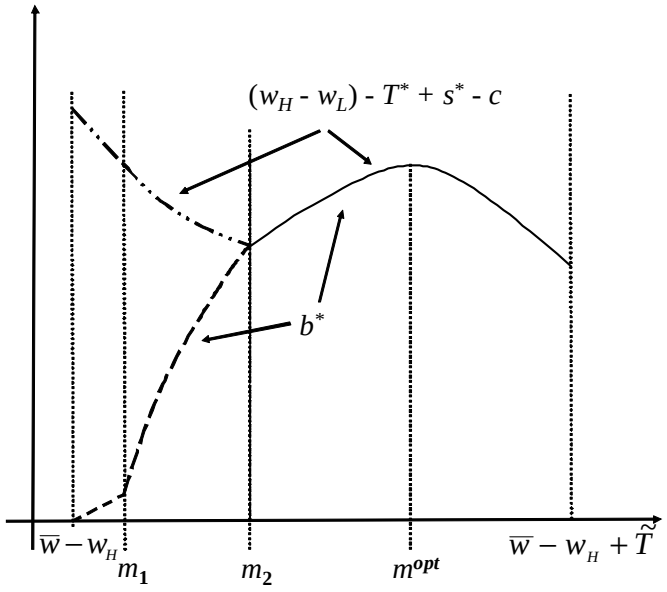

Figure 2: Net Incomes

The optimistic view of globalization finds support in our model when migration costs fall from a very high initial level. In the case of a closed or almost closed economy, taxes on skilled labor income are very high. As a result of the lack of commitment, the government has to implement a suboptimally high education subsidy as second-best policy to compensate for the future tax burden. Such a policy, however, carries real costs because collecting revenues pushes up administrative expenses. In this situation, enhanced mobility of human capital 'commits' the government to lower taxes. Yet the induced loss of revenues is outweighed by the drop in bureaucratic costs and education expenditures so that every unskilled worker can receive a higher transfer. Moreover, skilled workers are better off too, since the subsidy decreases by less than the tax payments. Therefore lower

migration costs implies a Pareto-improvement for $m \in \left[m^{opt}, \overline{w} - w_H + \widetilde{T}\right]$, where m^{opt} is defined as the value of m that maximizes $b(s^*(m), T^*(m))$. To be precise, an educated worker gains exactly the same amount as an unskilled worker because in the presence of a binding incentive constraint each individual receives the same net income adjusted for private investments in human capital, i.e., $w_H - T^* + s^* - c = w_L + b^*$ holds.

Our optimistic result turns into the opposite, however, once migration costs fall below the critical point m^{opt} at which the common net income peaks. While a further drop in the mobility costs continues to soften the government's commitment problem, the induced decline in administrative costs is not significant enough to compensate for the loss in revenues. The government has to reduce transfers. To limit the cuts in the consumption of unskilled households, resources are shifted from education to transfer spending. As a consequence, the education subsidy decreases more sharply than the tax payments of skilled workers, which makes them worse-off as well. Additionally, the reduced subsidy lowers the number of skilled workers.

While yet a further reduction in migration costs reduces the transfer to the unskilled, the consumption of the educated workers eventually increases. At low levels of m, declining migration costs narrow the gap between the tax and the education subsidy. Finally, the net burden $T^* - s^*$ equals zero at $m = \overline{w} - w_H$, where the net income of skilled workers adjusted for private education expenses reaches its 'global' maximum (see figure 2). 'Total' openness promotes the consumption of those individuals who can afford education without public support, but it does so at the expense of the unskilled population whose number grows. Our conclusions are summarized in

Proposition 3 *Net Incomes.*
(i) If $m \in [\overline{w} - w_H, m_2)$, transfer b^* and thus net income of unskilled workers $w_L + b^*(m)$ increase in migration costs m. By contrast, the net income of skilled workers $w_H - T^*(m) + s^*(m) - c$ reaches its global maximum at $m = \overline{w} - w_H$, where it equals $w_H - c$. It falls in m for low migration costs, but it is strictly larger than the net income of the unskilled if $m \in [\overline{w} - w_H, m_2)$.
(ii) If $m \in \left[m_2, \overline{w} - w_H + \widetilde{T}\right]$, net incomes of unskilled and skilled workers coincide ($w_L + b^* = w_H - T^* + s^* - c$). They first rise and then decline in migration costs m.
Proof. *See Appendix.*

We mentioned earlier the role of assumption 1 b) for our results, which says that for all possible levels of T, administrative costs of raising taxes are not too high relative to the social benefits of investing in skills. If the assumption were violated, the outlook would be much bleaker for sufficiently high migration costs. In this case, the incentive

constraint can only be fulfilled if the subsidy exceeds the net tax levied on the income of the skilled workers. This rules out any positive transfers to unskilled workers and therefore a redistributive government is not willing to support human capital formation. Individuals do not invest in education, anticipating high future taxes. In such a world redistribution is no longer feasible and the country ends up without skilled workers.

4.2 Wage Differentials and Government Inefficiency

Having analyzed the impact of declining migration costs on net incomes, we now explore how the 'optimal' openness and the consumption of skilled and unskilled workers are shaped by two exogenous parameters of the model: the foreign wage $\overline{w}$ and the degree of government inefficiency in tax collection. Consider first the implications of more attractive foreign earnings for skilled workers. An increase in the foreign net wage $\overline{w}$ lowers the optimal tax T^* by the same amount in order to prevent emigration (see Proposition 1). Graphically, the tax curve in figure 1 shifts to the right. The lines representing the subsidy, the transfer, and the net incomes in figures 1 and 2 also make a parallel shift to the right as they all depend on the tax. Consequently, all critical values like m_2 and m^{opt} move to the right.

The decline in tax T^* causes a fall in subsidies and thus in the number of skilled workers. In case of a *marginal* rise in $\overline{w}$, the transfer to the unskilled workers increases (decreases) if migration costs are above (below) the initially optimal level m^{opt}. This simply reflects the fact that a higher foreign net wage reinforces the effects of openness on transfers, which are positive for $m > m^{opt}$, but negative for $m < m^{opt}$. The shift in $\overline{w}$, moreover, increases the 'optimal' migration costs. Thus the larger the international wage gap $\overline{w} - w_H$ is, the less a redistributive government is in favor of openness. Note that even skilled workers might lose. For migration costs m between the 'new' level m_2 and the 'old' level m^{opt}, consumption of skilled workers decreases like consumption of unskilled workers. We summarize these insights in

Proposition 4 *Transfers and Outside Option.*
When the foreign net wage $\overline{w}$ rises marginally, the transfer to an unskilled worker increases (decreases) if the migration costs m are above (below) the originally optimal level m^{opt}. The transfer-maximizing migration costs m^{opt} rise.
Proof. *See Appendix.*

We are also interested in studying the comparative statics effects of exogenous changes in government efficiency. To this end, we specify the net tax function to be

$$t = \alpha f(T). \tag{14}$$

By modifying the parameter α, $\alpha_{min} < \alpha \leq 1$, changes in the efficiency of the tax bureaucracy is captured. A lower α means higher administrative costs of collecting tax T. The size of α does not affect the optimal tax policy in the third stage, which is only driven by the migration costs and the outside option for skilled workers. The parameter α determines the net tax t^* however. The more efficient the government collects taxes, the more resources are available for redistribution. Consequently, the transfer to an unskilled worker increases in α for all levels of migration costs. Furthermore, the optimal education subsidy s^o also increases in α, since a larger efficiency parameter yields a higher net tax and therefore makes public subsidies toward human capital accumulation more attractive. As the transfer to an unskilled workers rises, the minimum subsidy s^{min}, which guarantees that the incentive constraint is fulfilled, goes up by the same amount. In line with the education subsidy, the number of skilled workers increase in α for both intermediate and high migration costs. Since subsidies and transfers rise, skilled and unskilled workers are better-off. (See figure 3, which shows the curves of figure 2 for high (dotted line) intermediate (bold line) and low (broken line) levels of α.)

Proposition 5 *Transfers, Human Capital, and Government Efficiency.*
For all migration costs m, the transfer to an unskilled worker is larger, the higher the efficiency parameter α. The optimal education subsidies s^o and $s^{\min}$ increase in α, leading to more skilled workers for intermediate and high migration costs, and improving the consumption of all workers.
Proof. *See Appendix.*

Interestingly, there can be a non-monotonic relationship between α and the optimal openness m^{opt}.[11] Countries with sufficiently small and large values of α prefer rather small migration costs, while governments with intermediate administrative costs benefit from higher mobility costs (see again figure 3). To understand this claim, we relate the magnitudes of the potential globalization benefits to the administrative efficiency. Recall that a government with a redistributive objective can gain from lower mobility costs for two related reasons: First, globalization reduces administrative costs, and, second, it curbs suboptimally high education spendings. In combination, the benefits can outweigh a country's loss of revenues due to enhanced mobility. The first argument is particularly

[11] We do not prove this claim here formally, but discuss it intuitively. A formal proof is available upon request from the authors.

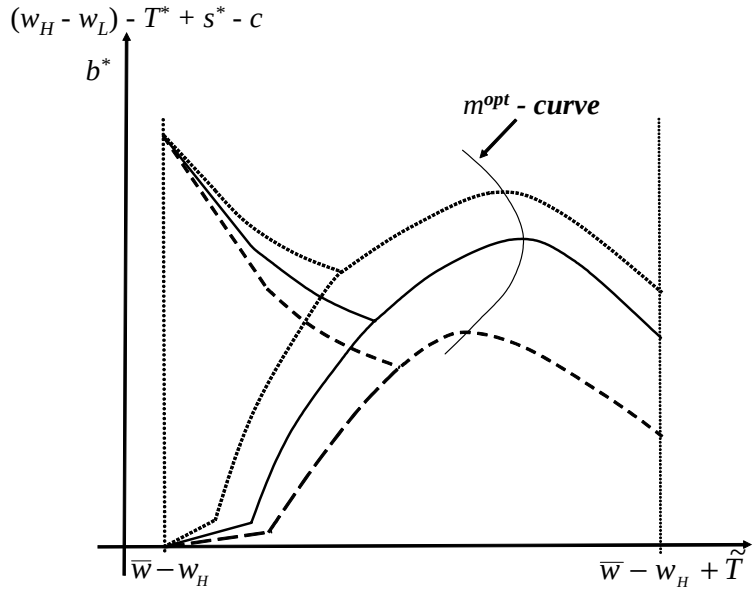

Figure 3: Transfers and Government Efficiency

important for a very inefficient government which suffers from high administrative costs. That is why the optimal migration costs m^{opt} can be rather low in this case.

To see why an efficient government can prefer low migration costs is less straightforward. Note, however, that a high value of α requires a particularly large education subsidy to overcome the hold-up problem (as argued above, s^{min} increases in α). Thus a rise in administrative efficiency further drives up the number of students which is already suboptimally large. Since globalization in the form of falling m curbs the high education spending and hence leaves more resources for transfers, an efficient government may favor rather small migration costs.

By contrast, in case of intermediate levels of α, the government might be more skeptical toward globalization. It this situation the government prefers larger migration costs than the efficient and very inefficient type, since the additional revenues are not completely exhausted by higher education spending (due to the limited number of the students) and administrative expenses (due to a sufficiently efficient bureaucracy). Thus, less openness yields a higher transfer to an unskilled worker.

5 Concluding Remarks

In this paper we have explored how declining mobility costs affect the income of skilled and unskilled workers when the government pursues a redistributive policy. Incentive and credit constraints in combination with administrative costs yield an inverse u-shaped relationship between transfers to the unskilled workers and openness. For sufficiently high migration costs, the recipients of transfers benefit from increasing mobility of human capital. But the positive effect of globalization is reversed once migration costs fall below a critical value. From the perspective of unskilled workers this threshold value constitutes the country's optimal openness. Moreover, starting from this point skilled workers too do not benefit from marginally lower migration costs, and the 'optimal' openness of the two income groups 'locally' coincides. Even the skilled workers who do not depend on public support for education are only better-off in case of a drastic further rise in mobility, since their net incomes recover for sufficiently low migration costs. But such low levels might be out of reach in the near future. Thus, an interesting implication of our analysis is that wealthy and less wealthy individuals may agree on the optimal degree of international mobility. To the extent that migration costs are influenced by governments, there need not be a conflict of interest between the income groups about migration policy.

Our analysis sheds light on the determinants or 'optimal' openness. First, the more attractive the outside option for skilled workers is, the higher the preferred migration costs from the perspective of a redistributive government. Second, both very efficient and very inefficient governments might prefer rather low migration costs compared to an administration with an intermediate level of α. This conclusion is in contrast to the line of reasoning that argues that internal reforms, like implementing a more efficient bureaucracy, are necessary before a country can take advantage of globalization. According to this view, a country should embrace free trade the more, the more efficient its administration works. We challenge this conclusion by showing that, depending in particular on the initial starting position, the 'optimal' openness might increase as well as decline if the tax administration becomes marginally more efficient.

The issue of international migration is likely to gain importance in the future. Facing aging societies and shortages of skilled workers in some professions, many industrialized countries have implemented or at least discussed reforms of their immigration laws. Even Germany, a country which traditionally provides only very limited opportunities for foreigners to stay permanently, has started to offer its version of a green card to foreign computer experts. More importantly perhaps, the eastern enlargement of the European Union enables skilled workers to search for jobs in the richer parts of the continent. In

terms of our model, this is equivalent to decreasing migration costs. Our analysis suggests that the welfare effects (from the perspective of the source countries) depend on the level of openness initially. For instance, restricting labor mobility between the old and the new EU member states for a transition period might well be in the interest of the relatively poor East European regions.

We conclude by pointing to two possible extensions of our formal analysis. First, by assuming exogenous wages we ignore any positive externalities from human capital. Our model therefore tends to underestimate the negative impact of brain drain. Second, we do not consider emigration of unskilled workers, although in practice less skilled workers participate in international labor migration to some degree. From the perspective of a redistributive government emigration of unskilled workers is beneficial because it reduces the number of transfer recipients. The absence of unskilled migration leads us to overestimate the consequences of brain drain. Both extensions should be examined in more detail in future work.

Appendix

Proof of Proposition 2: (i) Reformulating objective function (9) yields

$$V = \begin{cases} w_L & \text{if} \quad (7) \text{ is } \textit{not} \text{ fulfilled} \\ w_L + \frac{(t^* - s)E}{1-E} & \text{if} \quad (7) \text{ is fulfilled,} \end{cases} \tag{A1}$$

where, based on (10) and (11), the expected net tax $t^* = f(T^*(m))$ and the number of skilled workers who stay home $H = E$ are taken into account.

Note that at $m = \overline{w} - w_H$, we have $b = s = T^* = w_H + m - \overline{w} = 0$, and hence the incentive constraint (7) is not binding by Assumption 1. For slightly higher migration cost, the government can tax skilled workers without violating (7). There remains the question whether education subsidies should be implemented. Inserting $E = 1 - c + s$ into (13) yields

$$\frac{dV}{ds} = 1 - \frac{c - t^*}{(c-s)^2}. \tag{A2}$$

We now evaluate (A2) at $s = 0$ (noticing that $\partial^2 V / \partial s^2 = 2(t^* - c)/(c-s)^3 < 0$ by Assumption 1) and obtain

$$\left.\frac{dV}{ds}\right|_{s=0} = 1 - \frac{c - t^*}{c^2} \gtreqless 0 \qquad \Leftrightarrow \qquad t^* \gtreqless c\,(1-c)\,. \tag{A3}$$

A subsidy $s > 0$ affects transfer b positively only if the net tax t^* is larger than $c\,(1-c)$. Recall $t^* = f(T^*(m))$ depends positively on m. Thus there exists a migration cost level

m_1, for which $t^* = c(1-c)$, such that for all $m \leq m_1$ the optimal subsidy is zero, but is positive for $m > m_1$.

Once the migration costs exceed m_1, the optimal policy is given by the solution to the first-order condition $\partial V/\partial s = 0$, namely[12]

$$s^o = c - (c - t^*)^{1/2}. \tag{A4}$$

In this case, the subsidy increases in the enforceable net tax t^*, $t^* < c$ (by Assumption 1), and thus in mobility costs m, which follows directly from (A4).

Increasing migration costs narrow the consumption gap between skilled and unskilled households. Eventually the incentive constraint becomes binding. Substituting the budget constraint (4) and the optimal subsidy (A4) into the incentive constraint (7) gives

$$w_H - w_L - c - (T^* - t^*) - 1 + (c - t^*)^{1/2} \geq 0. \tag{A5}$$

The left side declines in m, since the administrative costs $T^* - t^*$ rise and the term $(c - t^*)^{1/2}$ falls in m. Consequently, there exists a critical value m_2 such that the solution s^o is not compatible with the incentive constraint for all $m > m_2$. The education subsidy s has to rise above the level s^o in order to overcome the commitment problem.[13] Thus the incentive constraint dictates a subsidy s^{min} for $m \geq m_2$. Inserting budget constraint (4) into (7) yields

$$(c - s)\Omega \geq t^* - s, \quad \text{where} \quad \Omega = w_H - w_L - c - (T^* - t^*). \tag{A6}$$

By Assumption 1 this inequality is always fulfilled when $\Omega \geq 1$. Hence, if the incentive constraint is binding, then $\Omega < 1$ must hold. In that case we can rewrite (A6) to obtain[14]

$$s \geq s^{min} = \frac{t^* - c\Omega}{1 - \Omega}, \tag{A7}$$

where $s^{min} < t^*$ holds. Thus s^o and s^{min} are the optimal subsidies in their respective intervals. The subsidy s^{min} increases in tax T and therefore also in migration costs. Formally, this conclusion follows from

$$\frac{ds^{min}}{dT^*} = \frac{\partial s^{min}}{\partial T^*} + \frac{\partial s^{min}}{\partial t^*}\frac{\partial t^*}{\partial T^*} = \frac{(1-\Omega)\,\partial t^*/\partial T^* + (1 - \partial t^*/\partial T^*)\,(c - t^*)}{(1-\Omega)^2} > 0, \tag{A8}$$

[12] There exists a second root to the quadratic equation in s, but at this value the second-order condition is violated and $s > c$ would hold, which is ruled out by Assumption 1.

[13] The increased spending ensures human capital accumulation in two ways. First, it directly enhances benefits from education reflected in an increase of the right side of incentive constraint (7). Second, an 'inefficient' high level $s > s^o$ curbs transfer b and therefore the left side of (7).

[14] We implicitly assume that there exist subintervals of m which imply $s^o > 0$ and $s^{min} > 0$ respectively. See our comments on this issue at the end of the proof.

since $\Omega < 1$ (as outlined above), $c > t^*$ (by Assumption 1) and $\partial t^*/\partial T^* < 1$ (see properties of (3)).

The optimal subsidy $s^*(m)$ is a continuous function, since it is continuous within each of the subintervals $[\overline{w} - w_H, m_1]$, $[m_1, m_2]$ and $\left[m_2, \overline{w} - w_H + \widetilde{T}\right]$, and because $s^o(m_1) = 0$ and $s^o(m_2) = s^{min}(m_2)$ hold. We implicitly assume here $m_1 < m_2 < \overline{w} - w_H + \widetilde{T}$. Equation (A3), however, does not rule out the possibility that even for $m = m_1$, and the resulting net tax $t^* = c\,(1-c)$, the incentive constraint is not fulfilled. Since the critical value m_2 may well lie below m_1, the interval $[m_1, m_2)$ can vanish. On the other hand, (A3) might hold for $m = \overline{w} - w_H + \widetilde{T}$, implying the net tax $t^* = \widetilde{t}$. In this case the incentive constraint never prevents the government from imposing the 'unrestricted' optimal subsidy s^o. In general, the lower the gross benefits from education $(w_H - w_L - c)$ and the higher the administrative costs $(T^* - t^*)$ are, the more elastic is the household response to government intervention and the lower is the threshold value m_2.

(ii) This conclusion directly follows from (8), (12) and the relation $s < c$ (see Assumption 1).

Proof of Proposition 3: (i) Inserting the optimal solution s^* into the second line of (A1) yields $V = w_L + t^*(1-c)/c$ for $m \in [\overline{w} - w_H, m_1]$ and $V = w_L + [1 - (c - t^*)^{1/2}]^2$ for $m \in (m_1, m_2]$. Both terms increase in t^* and thus in m.

If $m \in [\overline{w} - w_H, m_1]$, the adjusted net income of skilled workers $I_H(m) \equiv w_H - T^* + s^* - c$ amounts to $\overline{w} - m - c$ and therefore decreases in m. Moreover, $I_H(\overline{w} - w_H) = w_H - c > w_H - T^* + s^* - c = I_H(m)$ for $m \in \left(\overline{w} - w_H, \overline{w} - w_H + \widetilde{T}\right]$, since $s^* < t^* < T^*$ follows from (12) and Assumption 1.

(ii) In the interval $\left[m_2, \overline{w} - w_H + \widetilde{T}\right]$, the incentive constraint is binding, i.e. $w_H - T^* + s^* - c = w_L + b^*$ holds. We need to analyze only the impact of changes in m on transfer b^* to see the effect of migration costs on the adjusted net incomes of both skilled and unskilled workers. The two opposing effects of decreasing mobility can be seen from

$$\frac{dV}{dm} = \frac{dV}{dT^*} = \underbrace{\frac{\partial V}{\partial t^*}\frac{\partial t^*}{\partial T^*}}_{\text{direct effect}} + \underbrace{\frac{dV(s^{\min})}{ds}\frac{ds^{\min}}{dT^*}}_{\text{indirect effect}}. \tag{A9}$$

The direct impact is strictly positive as long as higher migration costs can be indeed transformed into a higher net tax ($\partial V/\partial t^* = E/(1-E) > 0$ and, if $t^* < \widetilde{t}$, $\partial t^*/\partial T^* > 0$). For $t^* = \widetilde{t}$, the derivative $\partial t^*/\partial T^*$ becomes zero, and the direct impact disappears. The indirect effect is negative for $s > s^o$, since $dV(s^{min})/ds < 0$ and $ds^{min}/dT^* > 0$ (see (A8)). It vanishes at $m = m_2$, where the minimum subsidy s^{min} coincides with the optimal 'unrestricted' solution s^o, since the marginal impact of the subsidy on welfare

equals zero at this point (for $s = s^o$, the first-order condition obviously holds and the envelope theorem can be applied). Thus, the transfer increases in migration costs at $m = m_2$, where only the strictly positive, direct impact appears. On the other hand, it declines in m at $\overline{w} - w_H + \widetilde{T}$ (where $t^* = \widetilde{t}$ and only the negative impact is left).

Furthermore, welfare V is strictly concave in the globalization parameter m, which follows from[15]

$$\begin{aligned}\frac{d^2V}{dm^2} = \frac{d^2V}{d(T^*)^2} = & \left(1 - \frac{c-t^*}{(1-\Omega)^2} + \frac{\Omega}{1-\Omega}\right)\frac{\partial^2 t^*}{\partial (T^*)^2} \\ & -2\left(1 - \frac{\partial t^*}{\partial T^*}\right)\frac{(1-\Omega)\partial t^*/\partial T^* + (c-t^*)(1-\partial t^*/\partial T^*)}{(1-\Omega)^3} < 0\end{aligned} . \tag{A10}$$

The term in the second line is negative, since $\partial t^*/\partial T^* < 1$, $0 < \Omega < 1$ and $c > t^*$ follow from the properties of (3), a binding incentive constraint, and assumption 1. Moreover, the expression in the first line is negative too, because $\partial^2 t^*/\partial (T^*)^2 < 0$, $0 < \Omega < 1$ and $1 \geq (c - t^*)/(1 - \Omega)^2$. The latter inequality can be derived by inserting (A7) into (A2): $dV/ds = 1 - (1 - \Omega)^2 / (c - t^*)$. Since $dV/ds \leq 0$ for $s^{min} \geq s^o$, $1 - (1 - \Omega)^2 / (c - t^*) \leq 0$ and thus $(c - t^*)/(1 - \Omega)^2 \leq 1$ if $m \geq m_2$.

Taken together, the above features, namely $dV/dm|_{m=m_2} > 0$, $dV/dm|_{m=\overline{w}-w_H+\widetilde{T}} < 0$ and $d^2V/dm^2 < 0$, lead to an inverse u-shaped relationship between the endogenous variable b and the exogenous parameter m in the interval $\left[m_2, \overline{w} - w_H + \widetilde{T}\right]$.

Proof of Proposition 4: Foreign net wage $\overline{w}$ only affects transfer b through the impact on T^* (see (10)). Thus, $dV/d\overline{w} = (dV/dT^*)(dT/d\overline{w}) = -(dV/dT^*)$, which implies $dV/d\overline{w} \gtreqless 0$ if and only if $m \lesseqgtr m^{opt}$.

Comparative statics shows

$$\frac{dm^{opt}}{d\overline{w}} = -\frac{d^2V/\left(dmd\overline{w}\right)}{d^2V/dm^2} = \frac{dV^2/d(T^*)^2}{dV^2/d(T^*)^2} = 1. \tag{A11}$$

Proof of Proposition 5: For low and intermediate migration costs, the marginal effect of α on transfers amounts to $dV/d\alpha = f(1-c)/c > 0$ and $dV/d\alpha = f[1-c+s^*]/[c-s^*] > 0$, respectively, where (13), (14), and (A1, second line) are taken into account. (Note that $ds/d\alpha = 0$ and $dV/ds|_{s=s^*} = 0$ hold for low and intermediate migration costs, respectively.)

For high migration costs, the corresponding term follows from (14) and $V = w_L + \Omega\left[1 - (c - t^*)/(1 - \Omega)\right]$ (see footnote 15):

$$\frac{dV}{d\alpha} = \left(\frac{1}{1-\Omega} - \frac{c-t}{(1-\Omega)^2}\right) f. \tag{A12}$$

[15] Inserting (A7) into (A1, second line) yields $V = w_L + \Omega\left[1 - (c - t^*)/(1 - \Omega)\right]$. This expression implies $dV/dT^* = -(1 - \partial t^*/\partial T^*)\left[1 - (c - t^*)/(1 - \Omega)^2\right] + (\partial t^*/\partial T^*)\,\Omega/(1 - \Omega)$, which is equivalent to (A9) and enables to calculate (A10) rather conveniently.

This expression is strictly positive, since $(c-t^*)/(1-\Omega)^2 \leq 1$ and $1/(1-\Omega) > 1$ hold for $s^{min} \geq s^o$ (see remarks after (A10)). Thus $dV/d\alpha > 0$ results over the whole domain of m.[16]

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[16] Note that this conclusion can be derived without considering how the efficiency parameter α shifts the threshold values m_1 and m_2. In fact, they decrease in α.

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