Education, Redistribution, and the Threat of Brain Drain

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Abstract

We analyze how the threat of brain affects redistributive government policies and net incomes of skilled and unskilled workers. Our analysis is based on a model that captures human capital formation, credit market constraints, and tax avoidance activities. We characterize how decreasing migration costs for skilled workers shape the time-consistent policies of a government that wants to shift resources from skilled to unskilled workers. Starting from a closed economy, declining migration costs first increase net incomes of both skilled and unskilled workers and then decrease net incomes of all households. Only for very low migration costs, there is a conflict of interest. In this case, skilled workers start to benefit from a further rise in their mobility, but now at the expense of the unskilled labor force.

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1 Introduction

International migration of skilled workers is an important phenomenon. In almost all countries individuals with tertiary education constitute the largest emigration group in relative terms (Docquier and Marfouk, 2006). Brain drain concerns middle and low income countries in particular, but is not limited to such countries. Even many wealthy industrial countries have lost about 10% and more of their highly qualified working force through emigration. For instance, more than 13% of the Austrians with tertiary education, almost 10% of their Dutch and 8% of their Danish counterparts have left their country, while the respective shares of medium-skilled and low-skilled workers are substantially lower.[1]

The debate over the merits of skilled migration and the increasing degree of competition for educated workers features two opposing views (like many other globalization debates). On the one hand the emigration of human capital gives rise to many concerns. 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 redistribution toward those who are less educated and less mobile, which in turn increases inequality. In addition it constraints a government'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. The significant returns to higher education investments - more than 8% in OECD countries and about 12% in Latin America and the Caribbean (Psacharopoulos, 1994) - can be seen as an indicator for underinvestment in human capital.

On the other hand better opportunities for skilled migration can be beneficial, and thus lead to a favorable view of globalization. When a redistributive government is unable to commit credibly to future tax schemes, the resulting time-consistent policy tends to overtax the returns to human capital, which in turn causes too little private investments in education (see, for instance, Boadway, Marceau and Marchand, 1996). The threat of brain drain softens

[1] See Docquier and Marfouk (2006) for details. Further evidence for and estimates of skilled migration is found in Becker et al. (2003) regarding Italy and Carrington and Detragiache (1998, 1999) regarding brain drain from developing to industrialized countries. Overviews of recent migration trends are given in OECD (2006a) and Wildasin (2000).

this well-known hold-up problem since it forces governments to curb taxes.[2] Such a policy change restores private incentives and might be beneficial to the society as a whole. In addition, a fall in tax rates for high income earners also diminishes incentives to search for tax avoidance strategies that reduce an individual's tax burden (like using deductions, tax arbitrage, and loopholes). Tax avoidance is costly from both a private and a social perspective, an issue particularly stressed by Feldstein (1999). Utilizing U.S. data, he argues that taxable income responds very elastically to changes in tax rates. According to his estimates, the revenue-maximizing rate might be below 40%, and the deadweight losses caused by the U.S. personal income tax amount to roughly one third of the tax revenue in 1994. Consequently, cutting top marginal income rates can yield substantial welfare gains and might even increase tax revenues.

In the current paper we analyze the above arguments in favor and against globalization within a unified framework. Since both lines of reasoning rest 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 - which result from either technological changes (such as better communication and transportation technology) or policy adjustments (such as dismantling legal barriers to international mobility) - affect the distribution of incomes of skilled and unskilled workers, government policy and human capital accumulation.

Our analysis provides several insights. Somewhat surprisingly we show that the signs of the welfare changes for skilled and unskilled workers due to globalization are often the same. More specifically, starting from a 'closed' economy declining migration costs of skilled workers first improve the consumption of both skilled *and* unskilled workers, and then worsen the consumption opportunities of *all* households. Only at sufficiently low migration costs the welfare changes go in opposite directions, and mobile skilled workers gain at the expense of the unskilled labor force.

The non-monotonic relationship between individual welfare and migration costs reflects

[2] There exists some empirical evidence for the decline in tax rates for skilled workers. Based on OECD (2004, 2006b), consider a worker who is single without children and earns 167% of the average manufacturing income (the highest income considered). In 1996, taxes and employee and employer social contributions less cash benefits of such a household type exceeded 50% of labor costs in eight EU countries. Nine years later, in 2005, this burden was lower in all these countries, and the decline over this period was up to 10%.

two opposing effects. On the one hand, lower migration costs increase the threat of brain drain, forcing the government to cut taxes on skilled workers. On the other hand, the decline in migration costs alleviates the time-consistency problem, enabling the government to reduce 'excessive' education subsidies to skilled workers, which are necessary to overcome the hold-up problem. When migration costs are high initially, the second effect dominates the first one, and more resources are available for redistribution. Skilled workers benefit from falling migration costs as well, since lower taxes and fewer costly tax avoidance activities overcompensate for diminishing education subsidies.

If migration costs fall below a critical level, the optimistic result is reversed, however. Enhanced mobility still mitigates the time-consistency problem, but this positive impact is fading; and growing migration pressure puts an even bigger strain on the government budget. Transfers to and net incomes of the unskilled workers decrease. Even skilled workers suffer from rising mobility. A lower tax on their incomes is more than offset by the decline in the education subsidy. The size of the skilled labor force is reduced when migration costs decline precisely because the education subsidy falls.

As a consequence of the opposing effects of globalization, transfers to the unskilled workers peak at a 'moderate' globalization level. The precise magnitude of this critical level depends on several factors. For instance, the poorer the country, as measured by the international wage differential for skilled workers, the higher are the transfer maximizing migration costs. In addition we show why a rising pay for skilled workers abroad increases the transfer to the unskilled workers at home for sufficiently high migration costs, and why it can make domestic skilled workers worse off.

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 (1998), Stark and Wang (2002) 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 claim that the opportunity of emigration can be beneficial for the source country, albeit for very different reasons because, unlike these papers, we explicitly consider the interaction between a redistributive tax scheme and education subsidies.

The second strand of literature related to our paper deals with redistribution and human capital formation when governments cannot commit to tax policies. Andersson and Konrad (2003a) 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 time-consistent taxation of high incomes and thus softens the hold-up problem. This conclusion is qualified in Andersson and Konrad (2003b). Although tax competition of two Leviathans reduces the hold-up problem, governments and individuals might be worse off in an open economy than in a closed economy because governments attempt to prevent education when emigration is possible.[3] Our paper also deals with possible problems of globalization. However, we stress the role of credit market constraints and tax avoidance activities absent in Andersson and Konrad (2003a, b), and characterize individual welfare as a continuous and non-monotonic function of migration costs.

Education and time-consistent policies are analyzed in some other papers too, but with a different focus. Thum and Uebelmesser (2003), for instance, consider intergenerational redistribution when gerontocratic governments use educational programs, which determine mobility costs, as commitment device to overcome the hold-up problem of human capital investment. The type of education affects mobility because skills can be country-specific or internationally applicable, a point that is also taken up in Poutvaara (2004). In another paper Poutvaara and Kanniainen (2000) show that social contracts of financing higher education on a national level break down when skilled workers can emigrate.[4]

The remainder of the paper is organized as follows: In the next section the basic framework is presented. We solve the model in section 3 and characterize the optimal tax and

[3] This conclusion shows that the evaluation of enhanced mobility depends very much on whether governments are assumed to be benevolent or not. Considering a government who is at least benevolent toward the unskilled workers, we pay no attention to the implications of rent-seeking politicians and political contests - like most of the literature we refer to.

[4] There is an array of other contributions on brain drain. For instance, Kuhn and McAusland (2006) discuss an alternative argument for beneficial brain drain. In their paper, a source country can gain from emigration if skilled workers produce abroad higher-quality "knowledge goods" that can be used by domestic customers. A prominent strand of literature analyzes optimal income taxation in the presence of emigration when governments have imperfect knowledge of workers' productivity at home *and* their opportunities abroad. See Wilson (2006) for a synthesis of this insightful research avenue.

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 and explore the role of international wage differentials. The final section summarizes our main results and concludes with a discussion of policy implications.

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 in terms of international mobility, and their impact on the model's key endogenous variables. The focus is on the small source country of migration and its (unilateral) policy. In this country, households decide on education, migration, and tax avoidance; and the government uses taxes, transfers, and education subsidies to redistribute from skilled, high-income workers to unskilled, low-income workers.

2.1 Households

We consider a continuum of individuals who live in a small open economy. Ex ante individuals differ only in their exogenous wealth y, which is uniformly distributed on the support $[0, 1]$. Each individual decides whether to become a skilled worker or not, which is a zero-one choice. If an individual remains unskilled, he supplies one unit of labor inelastically and earns w_L in the domestic labor market. In addition, he receives a government transfer b. His consumption is therefore $z^U = y + w_L + b$. By assumption unskilled workers are not mobile internationally.

To become a skilled worker, an individual needs to be educated. The government may provide an education subsidy s to cover partly education costs c so that an individual's private education costs are $c - s$. Reflecting credit market imperfections, we assume that an individual can invest in education only if her endowment y exceeds these private education costs $c - s$. Formally, the *credit constraint* is

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

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

To incorporate the empirical evidence that mobility increases with educational attainment, we allow skilled workers to emigrate - in contrast to the unskilled. A skilled worker's income thus depends on her migration decision (subsequent to her education choice). In case of emigration the individual earns wage $\overline{w}$ (net of foreign tax burden) gross of migration costs m. Since wealth is portable, consumption of a skilled migrant is $z^{SM} = y + \overline{w} - m - c + s$. Alternatively, a worker may stay in the source country and earns w_H in the domestic labor market. Since this labor income is reduced by tax costs T (as explained in more detail below), a skilled non-migrant's consumption in the source country reads $z^{SN} = y + w_H - T - c + s$.

For simplicity we assume that wages w_H and w_L are constant, perhaps due to technologies that exhibit constant marginal products. Similarly, wage $\overline{w}$ is constant for an exogenously given foreign tax burden. Furthermore, we assume $\overline{w} \geq w_H > w_L$, which reflects differential wages across countries and skill levels and sets the stage for 'brain drain' to occur.[5] In a dynamic framework the "wage" w could be interpreted more broadly as income. For example, high wage earners may accumulate wealth and thus receive capital income in addition to their wage income.

The individual *tax costs* T involve an individual's actual *tax payment* $t = \tau(w_H - a)$ and her *avoidance costs* k of reducing taxable income by a, i.e.,

$$T = t + k = \tau(w_H - a) + k(a), \tag{2}$$

where $\tau \in [0, 1]$ and $w_H - a$ stand for the constant tax rate and the taxable income, respectively. We allow skilled individuals to engage in tax avoidance activities a because high-income earners typically have substantial opportunities to exploit deductions, loopholes and tax arbitrage and to renegotiate tax saving compensation schemes with their employers.[6] Although there is a large variety of legal avoidance activities to reduce taxable income, we refer to a as tax deduction. Taxable income can be reduced by a skilled worker only at a cost

[5] Note that the relationship $\overline{w} \geq w_H$ captures both the case where gross wages differ across countries and the borderline case where gross wages are identical and potential host countries for migrants do not levy taxes.

[6] Feldstein (1995) and Slemrod and Bakija (1996, ch. 4 and 5) discuss legal avoidance strategies in more detail. Lindsay (1987) provides evidence that individuals with higher incomes adjust their avoidance behavior more strongly to changes in taxation than those with lower incomes.

(e.g., by hiring of tax consultants), however, and avoidance activities become more expensive as the extent of the manipulation increases. Hence we assume that avoidance costs k are a strictly convex and increasing function of tax deduction a with the properties (i) $k(0) = 0$, (ii) $\partial k(0)/\partial a = 0$, (iii) $\partial k(w_H)/\partial a = 1$, and (iv) $\left(\partial^2 k/\partial a^2\right)^2 \geq \left(\partial k/\partial a\right)\left(\partial^3 k/\partial a^3\right)$. The first property is straightforward. Conditions (ii) and (iii) guarantee that the individual's optimal choice a can later be expressed as a smooth and continuously differentiable function of tax rate τ over τ's whole domain $[0, 1]$, and are thus made for technical convenience. Similarly, condition (iv) implies that tax payments and costs respond well-behaved to changes in the tax rate. The assumptions are not particularly strong and are fulfilled, for instance, when $k(a) = \beta a^\alpha$, $\alpha > 1$, $\beta > 0$.

Summarizing the above, we can write an individual's consumption as

$$z = y + \begin{cases} \overline{w} - m - c + s & \text{if worker invests in skills and emigrates} \\ w_H - T - c + s & \text{if worker invests in skills and stays home} \\ w_L + b & \text{if worker remains unskilled.} \end{cases} \tag{3}$$

The different choices and outcomes are illustrated in figure 1. For convenience, we define *net wage* - in deviation from the common use of the term - as gross wage plus transfer net of tax payment and avoidance costs. So the domestic net wage of a skilled worker equals $w_H - T$, while its foreign counterpart is $\overline{w}$. Individuals maximize the amount available for consumption z.

- Insert Figure 1: Household Decisions -

2.2 Government and Sequence of Decisions

The government influences the decisions of individuals through three instruments, namely the tax rate τ, the transfer to unskilled workers b, and a uniform education subsidy s. The public sector budget constraint is given by

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

where E and H denote the total number of skilled individuals and the number of skilled workers not migrating, respectively. Expenditures on subsidies sE and transfers to unskilled workers $b(1-E)$ have to be covered by the tax payments from non-migrating skilled workers. The term on the right-hand side of the budget constraint already takes into account that all skilled workers staying at home pay the same tax. They earn the same gross wage and also choose the same deduction level a in equilibrium (as shown later).[7]

The government is assumed to pursue a redistributive objective by maximizing the net labor income of an unskilled worker, which is equivalent to maximizing the transfer to an unskilled worker. The government objective can be justified on political-economic grounds. Redistributive policies find support by the electorate given that unskilled workers (i.e., those without tertiary education) constitute the majority in most countries. We could highlight this point more prominently, for instance, by assuming that a fraction of the population lack the ability to become skilled. We omit such an assumption, however, because it would not provide any additional insights.

We finally describe the sequence of decisions, which is illustrated in figure 2: (1) Government implements education subsidy s, (2) households decide on education, (3) government implements tax τ and transfer b (for a given education subsidy and subject to a balanced budget), (4) skilled people decide on migration, and (5) non-migrant skilled workers decide on tax avoidance a. All individuals supply inelastically one unit of labor and, in the end, consume their income and their wealth after having paid taxes and received transfers. 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. We solve for the time-consistent outcome and characterize the equilibrium as a function of the migration cost parameter m and the international wage differential for skilled workers $\overline{w}-w_H$. All agents are rationally forward looking.

- Insert Figure 2: Sequence of Decisions -

[7]Note that the budget constraint (4) might be softened if the government used 'wealth-tested' subsidies and transfers as instruments. But even then the fundamental trade-offs analyzed in this paper would still exist as long as government revenue is constrained. And, as pointed out by the World Bank (1999, p. 52f), a downside of conditioning education subsidies on wealth is that this increases administrative and compliance costs so that the expected gains might not accrue. In section 5 we will reconsider the issue in the light of the full analysis.

3 Individual Choices and Government Policy

If a worker remains unskilled, no further decision of him needs to be analyzed. Thus we focus on the choices of the skilled workers and on government policy.

3.1 Tax Avoidance

If staying in the source country, the decision of a skilled non-migrant on tax avoidance is straightforward. Minimizing her tax costs T (see (2)), a taxpayer avoids taxes as long as the induced costs are below the tax savings, which gives the optimal level a as implicit solution to

$$\frac{\partial k(a)}{\partial a} = \tau. \tag{5}$$

This first-order condition in connection with properties (i) to (iii) of cost function k implies $a = k = 0$ for $\tau = 0$ (no avoidance without taxation) and $a = w_H$ for $\tau = 1$ (maximal deduction with confiscatory taxation). Moreover, condition (5) characterizes avoidance costs $k(a(\tau))$ as an increasing and convex function of the tax rate τ, as shown in the appendix (Lemma 1): A higher tax reinforces tax deduction a, which in turn yields a more than proportional rise in avoidance costs k. Additionally, we prove in the appendix (Lemma 2) that, in the absence of migration, the relationship between government revenue t and tax rate τ is of the Laffer-type. The maximum revenue per skilled worker that a government in a "closed" economy can extract equals $\widetilde{t} := t(\widetilde{\tau}) = \widetilde{\tau}\,[w_H - a(\widetilde{\tau})] < w_H$, where $\widetilde{\tau} := \arg\max t(\tau) \in (0, 1)$. The maximum tax is not confiscatory.

The Laffer-type relationship between revenues and tax rate is in line with Feldstein's (1995, 1999) findings. Stressing the sensitivity of individual tax avoidance behavior to tax policy, he shows that the 1993 tax legislation in the United States yields a fall in the tax payments of representative high-income earners, although their top marginal rate rose from 31% to almost 39%.[8] The substantial welfare losses that he measures in this context are reflected in our model by the avoidance costs. Alternatively, welfare losses can stem from labor supply reactions to taxation. Assuming inelastic labor supply, we exclude this possibility in our model. Instead, we focus on tax avoidance, since - according to Feldstein (1995, 1999)

[8] This result reconfirms Lindsay's (1987) estimates. He calculates that income tax revenues would peak at a tax rate of about 40%.

- the welfare losses of distortionary taxation substantially, and maybe predominantly, result from more aggressive avoidance activities. Ultimately, the source of the overall welfare loss, avoidance costs or labor supply distortions, does not matter for our basic conclusions.

3.2 Emigration of Skilled Workers

In the fourth stage a skilled worker compares her consumption level in the source country z^{SN} with her outside option z^{SM}. She anticipates her optimal avoidance strategy and the resulting domestic net wage. 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*

$$w_H - T \geq \overline{w} - m \tag{6}$$

is fulfilled. This condition requires that the migration costs m are higher than the international net wage differential (recall that domestic net wage is defined as gross wage net of tax payment and avoidance costs). Because wealth is assumed to be portable, condition (6) is independent of y and thus

$$H = \begin{cases} E & \text{if} \quad T \leq w_H + m - \overline{w} \\ 0 & \text{if} \quad T > w_H + m - \overline{w}. \end{cases} \tag{7}$$

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.

Before we analyze optimal tax policy, we restrict the parameter range for the migration costs without loss of generality:

Assumption 1 $m \in \left[\overline{w} - w_H, \overline{w} - w_H + \widetilde{T}\right]$.

Migration constraint (6) shows that for all $m \in (\overline{w} - w_H, \overline{w} - w_H + \widetilde{T})$, where $\widetilde{T} := T(\widetilde{\tau})$ is the tax costs resulting from the revenue maximizing tax rate $\widetilde{\tau}$ in a "closed" economy, the government can set a strictly positive tax rate without driving skilled workers out of the country. The resulting tax payment falls short of the maximum level $\widetilde{t}$. Only at the upper end of the migration cost interval, that is $m = \overline{w} - w_H + \widetilde{T}$, the possibility of brain drain does not restrict tax policy at all. The "maximum" tax rate $\widetilde{\tau}$ can be implemented, yielding revenue $\widetilde{t}$ per skilled worker. Essentially the latter case is equivalent to a situation of internationally immobile skilled workers. 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 is equivalent to perfect mobility of skilled workers. Considering values of m outside the interval $\left[\overline{w} - w_H, \overline{w} - w_H + \widetilde{T}\right]$ does not add any further insights.

3.3 Taxation of Skilled Non-Migrants and Redistribution

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

$$V = w_L + b = w_L + \frac{tH - sE}{1 - E}. \tag{8}$$

Maximizing welfare V is identical to maximizing the transfer to an unskilled household b. Taking the migration constraint (6) into account, the government chooses tax rate τ in the third stage to maximize (8). At that point the number of skilled people E and the subsidy s are given as results of previous decisions. Government revenue tH is the only remaining endogenous variable in the objective function (8), and the transfer b increases with tH.

The government faces two limits when maximizing these revenues. First, the tax payment t is at most $\widetilde{t}$ because the revenue function looks like a Laffer curve. Second, the threat of brain drain constrains the maximum tax costs T for educated workers to be equal to $w_H + m - \overline{w}$, which is the amount equalizing consumption 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. For migration costs $m \in \left(\overline{w} - w_H, \overline{w} - w_H + \widetilde{T}\right)$, the government collects some revenue but 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. Its optimal tax policy in stage 3 as well as the tax costs and payments are functions of migration costs, as summarized in

Proposition 1 *Optimal tax rate, tax costs, and tax payment.*

(i) The optimal tax rate $\tau^*(m)$ is implicitly defined by the binding migration constraint

$$T^* = \tau^*(w_H - a(\tau^*)) + k(a(\tau^*)) = w_H + m - \overline{w}.$$

The tax rate is increasing and convex in migration costs m. The corresponding tax costs $T^*(m) = w_H + m - \overline{w}$ range from $T^*|_{m=\overline{w}-w_H} = 0$ and $T^*|_{m=\overline{w}-w_H+\widetilde{T}} = \widetilde{T}$.

(ii) Tax payment $t^*(m)$ is increasing and concave in migration costs m, and it ranges from $t^*|_{m=\overline{w}-w_H} = 0$ to $t^*|_{m=\overline{w}-w_H+\widetilde{T}} = \widetilde{t}$.

Proof: See Appendix and preceding explanations.

Increasing migration costs enable the government to raise the tax rate such that individual tax costs increase by the same amount as migration costs, leading to $\partial T^*/\partial m = 1$. A higher tax rate, however, boosts avoidance activities. The individual tax payment rises less than tax costs, widening the gap between the two (which equals avoidance costs) as migration costs go up. These relationships are illustrated in figure 3.

- Insert Figure 3: Tax Costs, Tax Payment, and Education Subsidy -

The government implements the largest tax rate consistent with no migration. Therefore we can rewrite (7), the number of skilled workers staying in their home country, and obtain

$$H = E. \tag{9}$$

The transfer to the unskilled (see (8)) becomes

$$b = \frac{(t-s)E}{1-E}. \tag{10}$$

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

3.4 Skilled or Unskilled?

Households decide on education in the second stage for a given subsidy, anticipating tax policy and subsequent decisions. An individual *wants* 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*

$$\max\{\overline{w} - m, w_H - T^*\} - c + s \geq w_L + b \tag{11}$$

holds, where transfer b is given by (10). The left-hand side of (11) captures the net wage of a skilled worker adjusted for education spending. Making use of Proposition 1 (i), which says that domestic net wage equals its foreign counterpart gross of migration costs, i.e., $w_H - T^* = \overline{w} - m$, the left side equals $\overline{w} - m - c + s$. The right-hand side of (11) 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. Even if (11) holds, only those individuals whose initial wealth exceeds $c - s$ overcome the credit constraint (1) and *can* become skilled workers. The number of households for whom the credit constraint is not binding is $E = \int_{c-s}^{1} dy = 1 - (c - s)$, and thus the aggregate outcome of the education decision in the second stage is given by

$$E = \begin{cases} 0 & \text{if} \quad (11) \text{ is } \textit{not} \text{ fulfilled} \\ 1 - (c - s) & \text{if} \quad (11) \text{ is fulfilled.} \end{cases} \tag{12}$$

Before we move on we impose reasonable restrictions on the education costs relative to avoidance costs, tax payments, and gross wages.

Assumption 2 a) $\widetilde{t} < c$ b) $w_H - w_L - c > \widetilde{k}$.

Part a) implies that not all individuals can become skilled since the maximum tax payment - 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.[9] Part b) means that education is socially desirable in the absence of credit constraints because $\widetilde{k} := k(\widetilde{\tau}) > 0$ implies that the skilled wage exceeds the unskilled wage plus schooling costs. Moreover, the

[9] Assumption 2a) allows us in a simple way to focus on outcomes where some workers always remain unskilled. Alternatively, we could assume that individuals differ in their ability, and that some of them lack the ability to become skilled.

social benefit from education is larger than the avoidance costs per taxpayer at the maximum level of tax payments. Without this feature no individual would become skilled, as will be argued in section 4.

Assumption 2 has another important implication. For all policies (s, b, τ) which fulfill incentive constraint (11) and budget constraint (4), the domestic net wage of a skilled worker, $w_H - T$, 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.

3.5 Education Subsidy

We now turn to the analysis of the education subsidy s. When the government chooses the subsidy level, it anticipates the behavioral responses in all subsequent stages, in particular the induced investment in skills and the future tax policy. Individual decisions result from the credit constraint (1) and the incentive constraint (11). The interaction of the two 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 government's optimal subsidy in these intervals, which is illustrated in figure 3, and the number of skilled workers are stated in Proposition 2.

Proposition 2 *Optimal Education Decision and Subsidy.*

(i) The government's optimal education subsidy is

$$s^*(m) = \begin{cases} 0 & \text{if} \quad m \in [\overline{w} - w_H, m_1] \\ s^o = c - \sqrt{c - t^*} > 0 & \text{if} \quad m \in (m_1, m_2] \\ s^{\min} = \frac{t^* - c\Omega}{1 - \Omega} > s^o & \text{if} \quad m \in \left(m_2, \overline{w} - w_H + \widetilde{T}\right], \end{cases} \tag{13}$$

where $\Omega := w_H - w_L - c - k^*$ is used as short cut. The optimal subsidy s^* is a continuous function of migration costs 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 now give the economic intuition. First, from the perspective of a redistributive government education subsidies are an investment into the national tax base. Such an investment pays off only if the "return", i.e., the tax on the labor income of skilled workers, is sufficiently high. But there is no considerable "return" in the case of *low migration costs* ($m \leq m_1$) and thus a low tax t^*. In this situation, the government simply uses all revenues to transfer them to unskilled workers and sets the education subsidy to zero.

The optimal education subsidy becomes strictly positive in the case of *intermediate migration costs* ($m_1 < m \leq m_2$). On the one hand, the resulting 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 and the induced avoidance costs are 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 (11) 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 (1), and the subsidy that maximizes objective (8), called s^o, is characterized by the first-order condition

$$\frac{dV}{ds} = -\frac{E}{1-E} + \frac{t^* - s}{(1-E)^2} = 0, \tag{14}$$

where we make use of $E = H = 1-(c-s)$ (see (9), (10), and (12)). A larger education subsidy ties up government resources not available for redistribution. This direct spending effect is negative (see first term of (14)). In the opposite direction works the second, indirect effect, which we term the "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 increases transfer b if the education subsidy s falls short of the expected tax t^* (see second term of (14)). Moreover, the positive "social composition effect" is larger, the higher the tax payment t^*. A higher future tax makes it more attractive to promote individuals to become skilled. Consequently, the optimal subsidy s^o increases with t^* and thus with 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.* Now, the time-consistency problem arises: Private investment in education is unprofitable unless a "suboptimally" high education subsidy is granted in the first stage because high migration costs lead to high tax costs T and a low net wage $w_H - T$. The education subsidy does not aim at "optimally" overcoming the credit constraint, but its purpose is to overcome the binding incentive constraint (11) and to ensure that individuals *want* to attend school. The government sets s so that the incentive constraint (11) is just fulfilled. The subsidy, denoted s^{min}, is above the level s^o and serves as a second-best tool to compensate for the government's inability to commit to a lower tax in the third stage. The subsidy is larger, the higher the tax on skilled workers. Consequently, s^{min} is positively related to the migration costs.

Putting the insights for the three parameter ranges together, the number of people who can afford to attend school and become skilled goes up with migration costs, as the subsidy (weakly) increases with the migration costs over the whole domain of m. The reasons for the rising education subsidy depend on the size of migration costs. For low and intermediate migration costs, the credit constraint (1) drives the optimal subsidy. By contrast, for high migration costs, the incentive constraint (11) and the underlying time-consistency problem determine the education subsidy. However, the optimal subsidy is never sufficient to cover total school costs so that some individuals always remain unskilled (i.e., $E < 1$).

4 The Welfare Effects of Globalization and International Wage Differentials

We are now in a position to analyze the impact of globalization, i.e., a decrease in migration costs, on the net incomes and consumption levels of skilled and unskilled workers. The next section shows not only why the relationships are non-monotonic, but also establishes the existence of a common level of migration costs at which consumption of both income groups peaks. Section 4.2 further explores how this consumption peak and the net incomes depend on the international wage differential.

4.1 Redistribution and Migration Costs

The equilibrium policy yields an inverse u-shaped (or a bell-shaped) relationship between the net income of *unskilled* workers and migration costs. Moreover, the relation between the net wage of *skilled* workers minus private education costs on the one hand and migration costs on the other hand is $\backsim$-shaped. These two features together mean that starting from a sufficiently high m both groups first gain from globalization, then both groups lose, and finally the skilled workers gain while the unskilled workers lose. We explain these results step by step, and illustrate them in figure 4 (for convenience, the net incomes adjusted for private education spending *minus* the constant w_L are shown in figure 4).

- *Insert Figure 4: Net Incomes and Migration Costs* -

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, the government faces a severe time-consistency problem. The skilled workers' tax costs $T^* = t^* + k^*$ are very high and the incentive constraint is tight, which in turn restricts education policy. The government has to implement a suboptimally high education subsidy as second-best policy to compensate for the future individual tax costs. A decline in migration costs alleviates this time-consistency problem. It softens the incentive constraint because enhanced mobility 'commits' the government to lower taxes. Tax costs drop in line with migration costs, which enables the government to cut the education subsidy s^* substantially. The individual tax payment t^* falls only moderately (because lower tax costs stem mostly from declining avoidance costs k^* in response to tax cuts, as shown in figure 3). The net contribution of each skilled worker to the government budget, $t^* - s^*$, rises. As a result, the government can raise the transfer b^* to each unskilled worker, even though a falling education subsidy - which implies fewer skilled workers - increases the number of recipients.

Moreover, skilled workers are better off too as the subsidy s^* decreases by less than the tax costs T^*. 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., $w_H -$

$T^* - c + s^* = w_L + b^*$ holds. Therefore lower migration costs imply a Pareto-improvement for $m \in \left[m^{max}, \overline{w} - w_H + \widetilde{T}\right]$, where m^{max} is defined as the value of m at which transfer b^* reaches its maximum.

Our optimistic result turns into the opposite, however, once migration costs fall below the critical point m^{max}, at which the common adjusted net income peaks. A further drop in the migration costs continues to soften the still binding incentive constraint, and thus to alleviate the time-consistency problem. But the associated positive effect is now less significant. By contrast, the negative impact of the growing migration pressure gains prominence. In response to declining individual tax payments, the government cuts the education subsidy even more, thereby further tightening the credit constraint. Consequently, the proportion of transfer recipients to tax payers reaches higher levels. The government is forced to reduce transfers, which diminishes the consumption of unskilled workers. Skilled workers are worse off as well, since the education subsidy now decreases more sharply than the tax costs. We conclude that declining migration costs are Pareto worsening for $m \in [m_2, m^{max}]$.

Once migration costs are below the critical value m_2, the incentive constraint is not binding anymore, and net incomes of skilled and unskilled workers fall apart, as illustrated in figure 4. Migration pressure severely limits taxation and thus education and welfare spending. For $m \in [\overline{w} - w_H, m_2]$, the consumption of those individuals who can afford education with little or no public support ultimately recovers in response to enhanced mobility, but it does so at the expense of the immobile, unskilled individuals whose number grow.[10] Finally, tax, subsidy and transfer equal zero at $m = \overline{w} - w_H$. At that level of m the net income of the remaining skilled workers (adjusted for private education expenses) reaches its 'global' maximum, while the net income of the unskilled falls to its minimum. Our conclusions are summarized in

Proposition 3 *Net Incomes and Migration Costs.*

(i) If $m \in [\overline{w} - w_H, m_2)$, transfer $b^*(m)$ and thus net income of unskilled workers $w_L + b^*(m)$

[10] In general, the consumption level of the skilled workers might reach a local minimum at any migration cost level $m \in [m_1, m_2]$. It can be shown, however, that it strictly decreases with m for all $m \in [m_1, m_2]$ if the skilled workers (i.e., those with tertiary education) constitute less than 50% of the population. This is shown in figure 4. The sufficient condition $E \leq 0.5$ is not particularly restrictive and consistent with our assumption that the government redistributes towards the unskilled.

increase with migration costs m. By contrast, the adjusted net income of skilled workers $w_H - T^*(m) - c + s^*(m)$ reaches its global maximum at $m = \overline{w} - w_H$, where it equals $w_H - c$, and falls with m for low migration costs. For all $m < m_2$ the net income of skilled workers exceeds the net income of unskilled workers.

(ii) If $m \in \left[m_2, \overline{w} - w_H + \widetilde{T}\right]$, net incomes of unskilled and skilled workers adjusted for private education costs coincide ($w_L + b^* = w_H - T^* - c + s^*$). Both types of incomes first rise and then decline with migration costs m.

Proof: See Appendix.

We mentioned earlier the role of assumption 2 b), which says that for all possible tax rates τ, avoidance costs 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 could only be fulfilled if the subsidy exceeded the tax payment of a skilled worker, which rules out any positive transfers to unskilled workers. Therefore a redistributive government would not be willing to support human capital formation. Anticipating high future taxes, individuals would consequently not invest in education. In such a world redistribution is no longer feasible and the country ends up without skilled workers.

4.2 International Wage Differential

Next we explore how equilibrium government policy and consumption possibilities are influenced by the size of the foreign wage $\overline{w}$. In response to an increase in the foreign net wage $\overline{w}$, i.e., a growing international wage differential, tax costs T^* have to fall by the same amount in order to prevent emigration for given migration costs m. The optimal tax rate τ^* has to decline correspondingly. The ensuing decline in tax payment t^* causes a fall in subsidies and thus in the number of skilled workers.

Graphically, the curves of the tax costs, the tax payment and the subsidy in figure 3 shift to the right. The lines representing the net incomes in figure 4 also make a parallel shift to the right as they depend on the tax policy. Consequently, all critical values like m_2 and m^{max} move to the right. The implications on net incomes are stated in

Proposition 4 *Net Incomes and Outside Option.*

Consider a marginal rise in foreign net wage $\overline{w}$ *for given migration costs* m*:*

(i) Transfer b^* *and thus net income of unskilled workers* $w+b^*$ *increases (decreases) with* $\overline{w}$ *if the migration costs* m *are above (below) the initial critical level* $m^{\max}$*. The critical migration cost level* $m^{\max}$ *rises with foreign net wage* $\overline{w}$*.*

(ii)The adjusted net income of skilled workers $w_H - T^* - c + s^*$ *decreases with* $\overline{w}$ *for* $m \in (m_2, m^{\max})$*. It increases with* $\overline{w}$ *for* $m > m^{\max}$ *and for low migration costs* $(m \leq m_1)$*.*

Proof: See Appendix.

The proposition reflects the fact that an increase in the foreign net wage is a perfect substitute for a decrease in migration costs. Both changes make emigration more attractive, thereby further limiting taxation. A higher foreign wage thus alleviates the time consistency problem and enables the government to cut education subsidies. But only if migration costs are above the critical value m^{max}, this positive effect is so strong that the government can raise transfers to the unskilled workers. Otherwise, transfers have to be cut in response to lower taxes. Then unskilled workers in the source country are indeed worse off, the higher the foreign wage $\overline{w}$. Perhaps surprisingly, mobile skilled workers may also lose if their outside option becomes more attractive. A higher foreign wage constrains domestic taxation. For migration costs m between the critical levels m_2 and m^{max}, however, the decline in tax costs cannot compensate for the fall in the education subsidy. As a result, net income of skilled workers adjusted for private education costs decreases despite a rising threat of brain drain.

5 Concluding Remarks

In this paper we have explored how the growing threat of brain drain affects the income of skilled and unskilled workers when the government pursues a redistributive policy. We have shown that the consumption opportunities of the two income groups move in the same direction for a certain range of migration costs. Starting from a closed economy, declining migration costs of skilled workers first increase net income (adjusted for private education costs) of both skilled and unskilled workers and then decrease net income of all households.

Only for sufficiently low migration costs there is a conflict of interest. In this case, skilled workers start to benefit again from a further rise in their mobility, but now at the expense of the unskilled labor force. Such low levels, however, might be out of reach in the near future, as long as many cultural and political barriers to migration exist.

In addition, our analysis shows that the sign of the welfare effect of potential migration depends on the precise circumstances in a country. The critical migration cost level at which the transfer peaks and the threshold level below which the interests between skilled and unskilled workers diverge are higher, the relatively less wealthy the sending country. The relationship between international wage gaps and threshold levels has an important implication: For a given initial level of migration costs, a marginal rise in the mobility of human capital can be beneficial to all workers in a relatively rich country facing only a small wage gap, hurt all households in a relatively less rich country, and it can cause a severe conflict of interest in a relatively poor country. Political attitudes toward globalization in terms of human capital mobility should diverge between countries with different income levels accordingly.

Moreover, we have analyzed the implication of growing international wage gaps. A higher foreign net wage for skilled workers can be to the advantage of immobile, unskilled workers at home and to the disadvantage of the mobile, skilled workers - depending on migration costs. All in all, our simple model suggests that when we explore the implications of declining migration costs, we should pay more attention to the specific situation in the country considered. Our analysis provides some rough guidelines.

We conclude with two remarks on specific features of our model. First, note that the *threat* of brain drain is crucial, not the actual brain drain itself. Indeed, in our model no migration occurs in equilibrium. To capture real flows of skilled workers more precisely, we could incorporate heterogeneity regarding migration costs so that some skilled workers emigrate and some stay at home. We believe that this additional feature, however, would come at the price of a more complicated model without adding substantial further insights. Moreover, the current approach stresses that the decline in migration costs should affect policy and income distribution even if it does not cause migration flows.

Finally, we take up our previous remarks on alternative policy instruments. As mentioned in section 2, ‘wealth-tested’ subsidies and transfers might soften the government’s budget constraint. A glance at an individual’s incentive constraint, however, shows that they can only be used to a limited extend: If the tax is sufficiently high, even wealthy people have to receive a subsidy. In this sense, ‘wealth-tested’ instruments would not alter the basic relationships qualitatively - the hold-up problem would still exist. Besides, the additional administrative and compliance costs might reduce or even eliminate the expected gains. Similarly, implementing loan schemes instead of subsidies are often not financially worthwhile from the government’s perspective. The administrative and compliance costs of loans to finance education are substantial for well-known reasons, particularly when skilled workers are internationally mobile. Moreover, loans are useless as a substitute for subsidies to overcome the incentive constraint.

Appendix

We first state and prove two results relating to the properties of avoidance cost and tax functions.

Lemma 1 *In the taxpayer's optimum, the avoidance costs $k(a(\tau))$ are increasing and convex in the tax rate τ.*

Proof: Using first-order condition (5), comparative statics give

$$\frac{\partial a(\tau)}{\partial \tau} = \frac{1}{\partial^2 k/\partial a^2} > 0 \qquad \text{and} \qquad \frac{\partial^2 a(\tau)}{\partial \tau^2} = -\frac{\partial^3 k/\partial a^3}{\left(\partial^2 k/\partial a^2\right)^3}. \tag{A1}$$

These results enable us to calculate

$$\frac{\partial k(a(\tau))}{\partial \tau} = \frac{\partial k/\partial a}{\partial^2 k/\partial a^2} \geq 0 \text{ and } \frac{\partial^2 k(a(\tau))}{\partial \tau^2} = \frac{\left(\partial^2 k/\partial a^2\right)^2 - \left(\partial k/\partial a\right)\left(\partial^3 k/\partial a^3\right)}{\left(\partial^2 k/\partial a^2\right)^3} \geq 0, \tag{A2}$$

where the signs follow from the strict convexity of the function $k(a)$ and its properties (ii) and (iv).

Lemma 1 implies furthermore a clear-cut relationship between tax costs $T = t + k$ and the tax rate. Defining $f(\tau) := \tau\left[w_H - a(\tau)\right]$ and $\widetilde{\tau} := \arg\max f(\tau)$, we can state

Lemma 2 *(i) The tax payment t is strictly concave in the tax rate $\tau \in [0,1]$, strictly increasing in τ for $\tau \in [0, \widetilde{\tau})$, and strictly decreasing for $\tau \in (\widetilde{\tau}, 1]$. Also, t is strictly positive for $\tau = \widetilde{\tau}$, but equals zero for $\tau = 0$ and $\tau = 1$.*

(ii) Total costs $T = t + k$ are increasing and strictly concave in the tax rate τ.

Proof: (i) Differentiating $t = f(\tau)$ and using (A1) and (A2) yield

$$\frac{\partial f(\tau)}{\partial \tau} = (w_H - a) - \tau\frac{\partial a}{\partial \tau} \qquad \text{and} \qquad \frac{\partial^2 f(\tau)}{\partial \tau^2} = -\frac{\partial a}{\partial \tau} - \frac{\partial^2 k(a(\tau))}{\partial \tau^2} < 0. \tag{A3}$$

This proves the first part of Lemma 1. The second part follows directly from $\partial f(0)/\partial \tau = w_H > 0$, $\partial f(1)/\partial \tau = -\partial a/\partial \tau < 0$ and the strict concavity of f, implying $\widetilde{\tau} : \partial f(\tau)/\partial \tau \gtreqless 0 \Leftrightarrow \tau \lesseqgtr \widetilde{\tau} \in (0,1)$. (Recall that $a(0) = 0$ and $a(1) = w_H$.) Thus, $f(\widetilde{\tau}) > f(0) = f(1) = 0$ results (third part).

(ii) Using the envelope theorem, simple differentiation yields

$$\frac{dT(\tau, a(\tau))}{d\tau} = \frac{\partial T}{\partial \tau} = w_H - a \geq 0 \Leftrightarrow \tau \leq 1 \qquad \text{and} \qquad \frac{d^2T}{d\tau^2} = \frac{\partial^2 T}{\partial \tau^2} = -\frac{\partial a}{\partial \tau} < 0. \tag{A4}$$

Proof of Proposition 1 (i): The previous result $\partial t/\partial \tau \geq 0$ for $\tau \in [0, \widetilde{\tau}]$ (see Lemma 2) implies that τ^* is the maximum tax rate that fulfills migration constraint (6) for $m \in \left[\overline{w} - w_H, \overline{w} - w_H + \widetilde{T}\right]$, yielding $\tau^*|_{m=\overline{w}-w_H} = 0$ and $\tau^*|_{m=\overline{w}-w_H+\widetilde{T}} = \widetilde{\tau}$ at the lower and upper bound of m. Using (2), (6) and (A4), comparative statics leads to

$$\frac{d\tau^*}{dm} = \left(\frac{\partial T^*}{\partial \tau^*}\right)^{-1} > 0 \qquad \text{and} \qquad \frac{d^2\tau^*}{dm^2} = -\frac{\partial^2 T^*/\partial(\tau^*)^2}{\left(\partial T^*/\partial \tau^*\right)^3} > 0. \tag{A5}$$

Tax costs $T^*(m)$ are directly defined by migration constraint (6). Before we proceed to prove Proposition 1 (ii), we state and prove

Lemma 3: *Tax avoidance costs $k^*(m)$ are increasing and convex in migration costs m.*

Proof. Derivatives (A2) and (A5) lead to $dk^*/dm = (\partial k^*/\partial \tau^*)\,(d\tau^*/dm) \geq 0$ and $d^2k^*/dm^2 = [\partial^2 k^*/\partial(\tau^*)^2]\,(d\tau^*/dm)^2 + (\partial k^*/\partial \tau^*)\,(d^2\tau^*/dm^2) \geq 0$.

Proof of Proposition 1 (ii): First, $dt^*/dm = (\partial t^*/\partial \tau^*)\,(d\tau^*/dm) \geq 0$ holds (see proof of Lemma 2 (i) and (A5)). Second, $\partial T^*/\partial m = 1$ (implied by Proposition 1 (i)) and $d^2k^*/dm^2 \geq 0$ (see Lemma 3) lead to $d^2T^*/dm^2 = 0 \Leftrightarrow d^2t^*/dm^2 + d^2k^*/dm^2 = 0 \Leftrightarrow d^2t^*/dm^2 = -d^2k^*/dm^2 \leq 0$.

Proof of Proposition 2: (i) Reformulating objective function (8) yields

$$V = \begin{cases} w_L & \text{if } (11) \text{ is } \textit{not} \text{ fulfilled} \\ w_L + \frac{(t^*-s)E}{1-E} & \text{if } (11) \text{ is fulfilled,} \end{cases} \tag{A6}$$

where the expected tax payment $t^* = f(\tau^*(m))$ and transfer (10) 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 (11) is not binding by Assumption 2 b). For slightly higher migration costs, the government can tax skilled workers without violating (11). There remains the question whether education subsidies should be implemented. From the first order condition for maximizing V with respect to s, and inserting $E = 1 - c + s$ (see also (14)), we find

$$\frac{dV}{ds} = 1 - \frac{c - t^*}{(c - s)^2}. \tag{A7}$$

We now evaluate (A7) at $s = 0$ (noticing that $\partial^2 V/\partial s^2 = 2(t^* - c)/(c - s)^3 < 0$ by Assumption 2) and obtain

$$\left.\frac{dV}{ds}\right|_{s=0} = 1 - \frac{c - t^*}{c^2} \gtreqless 0 \qquad \Leftrightarrow \qquad t^* \gtreqless c\,(1 - c)\,. \tag{A8}$$

A subsidy $s > 0$ affects transfer b positively only if the tax payment t^* is larger than $c\,(1 - c)$. Recall that $t^* = f(\tau^*(m))$ 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[11]

$$s^o = c - (c - t^*)^{1/2}\,. \tag{A9}$$

In this case, the subsidy increases in the enforceable tax payment t^*, $t^* < c$ (by Assumption 2), and thus in migration costs m, which follows directly from (A9).

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 (A9) into the incentive constraint (11) gives

$$w_H - w_L - c - k^* - 1 + (c - t^*)^{1/2} \geq 0. \tag{A10}$$

The left side declines in m, since the avoidance costs k^* 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.[12] Thus the incentive constraint

[11] 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 2.

[12] The increased spending ensures human capital accumulation in two ways. First, it directly enhances benefits from education, which is reflected in an increase of the left side of incentive constraint (11). Second, an 'inefficient' high level $s > s^o$ curbs transfer b and therefore the right side of (11).

dictates a subsidy s^{min} for $m \geq m_2$. Inserting budget constraint (4) into (11) yields

$$(c - s)\Omega \geq t^* - s, \quad \text{where} \quad \Omega = w_H - w_L - c - k^*. \tag{A11}$$

By Assumption 2, 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 (A11) to obtain[13]

$$s \geq s^{min} = \frac{t^* - c\Omega}{1 - \Omega}, \tag{A12}$$

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 the tax rate τ and therefore also in migration costs. Formally, the conclusion follows from

$$\begin{aligned}
\frac{ds^{min}}{d\tau^*}\frac{d\tau^*}{dm} &= \left(\frac{\partial s^{min}}{\partial t^*}\frac{\partial t^*}{\partial \tau^*} + \frac{\partial s^{min}}{\partial k^*}\frac{\partial k^*}{\partial \tau^*}\right)\frac{d\tau^*}{dm} \\
&= \left(\frac{(1-\Omega)\,\partial t^*/\partial \tau^* + \partial k^*/\partial \tau^*\,(c - t^*)}{(1-\Omega)^2}\right)\frac{d\tau^*}{dm} > 0,
\end{aligned} \tag{A13}$$

since $\Omega < 1$ (as outlined above), $c > t^*$ (by Assumption 2), $\partial t^*/\partial \tau^* \geq 0$ (see Lemma 2 (i)), and $\partial k^*/\partial \tau^* > 0$ for $\tau > 0$ (see (A2)).

The optimal subsidy $s^*(m)$ is a continuous function, because 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 $m_1 < m_2 < \overline{w} - w_H + \widetilde{T}$: That is, there exists (a) an interval $[m_1, m_2)$ such that $s^o(m) \geq 0$ and $s^o(m) > s^{min}(m)$, and (b) an interval $\left(m_2, \overline{w} - w_H + \widetilde{T}\right]$ such that $s^{min}(m) \geq 0$ and $s^{min}(m) > s^o(m)$. Depending on the parameter values, however, $s^o(m_1) = 0 < s^{min}(m_1)$ may result. This means that even for the tax payment $t^* = c\,(1 - c)$ (which implicitely defines m_1, see (A8)), the incentive constraint (11) is only fulfilled if a "suboptimally" high subsidy $s^{min}(m) > s^o(m)$ is implemented. Then the interval $[m_1, m_2)$ "vanishes". On the other hand, $s^o|_{m=\overline{w}-w_H+\widetilde{T}} > s^{min}|_{m=\overline{w}-w_H+\widetilde{T}}$ may hold, meaning that the incentive constraint (11) never prevents the government from imposing the "unrestricted" optimal subsidy s^o. Then the interval $\left[m_2, \overline{w} - w_H + \widetilde{T}\right]$ "vanishes". In general, the lower the gross benefits from education $(w_H - w_L - c)$ and the higher the avoidance costs k^*, the more elastic is the households' response to government intervention and the lower is the threshold value m_2.

[13] 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.

(ii) This conclusion directly follows from (12), (13) and the relation $s \in [0, c)$ (see Assumption 1).

Proof of Proposition 3: (i) Inserting the optimal solution s^* into the second line of (A6) 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 τ^* and m.

If $m \in [\overline{w} - w_H, m_1]$, the adjusted net income of skilled workers $I_H(m) := w_H - T^* + s^* - c$ 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 (13) and Assumption 2.

(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

$$\frac{dV}{dm} = \frac{dV}{d\tau^*}\frac{d\tau^*}{dm} = \underbrace{\frac{\partial V}{\partial t^*}\frac{\partial t^*}{\partial \tau^*}\frac{d\tau^*}{dm}}_{\text{direct effect}} + \underbrace{\frac{dV(s^{\min})}{ds}\frac{ds^{\min}}{d\tau^*}\frac{d\tau^*}{dm}}_{\text{indirect effect}}. \tag{A14}$$

The direct impact is strictly positive as long as higher migration costs can be indeed transformed into a higher tax payment ($\partial V/\partial t^* = E/(1-E) > 0$, $\partial t^*/\partial \tau^* > 0$ for $\tau^* < \widetilde{\tau}$ according to Lemma 2 (i), and $d\tau^*/dm > 0$ according to Proposition 1(i)). For $\tau^* = \widetilde{\tau}$, the derivative $\partial t^*/\partial \tau^*$ becomes zero, and the direct impact disappears. The indirect effect is negative for $s > s^o$, since $dV(s^{min})/ds < 0$ and $\left(ds^{min}/d\tau^*\right)(d\tau^*/dm) > 0$ (see (A13)). It vanishes at $m = m_2$, where the minimum subsidy s^{min} coincides with the optimal 'unrestricted' solution s^o, because 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).

Finally, we show that welfare V is single-peaked in the globalization parameter m, meaning that there exists a critical value m^{max} such that $dV/dm \gtreqless 0 \Leftrightarrow m \lesseqgtr m^{max}$. Since $d\tau^*/dm > 0$, $dV/dm \gtreqless 0 \Leftrightarrow dV/d\tau^* \gtreqless 0$ holds. Thus, single-peakedness of welfare V follows from[14]

$$\begin{aligned} \frac{d^2V}{d\tau^2} = & -\left(1-\frac{c-t^*}{(1-\Omega)^2}\right)\frac{\partial^2 k^*}{\partial(\tau^*)^2}+\frac{\Omega}{1-\Omega}\frac{\partial^2 t^*}{\partial(\tau^*)^2} \\ & -2\frac{\partial k^*}{\partial\tau^*}\frac{(1-\Omega)\partial t^*/\partial\tau^*+(c-t^*)\partial k^*/\partial\tau^*}{(1-\Omega)^3}<0 \end{aligned}. \tag{A15}$$

The term in the second line is negative, since $\partial k^*/\partial\tau^* \geq 0$, $\partial t^*/\partial\tau^* \geq 0$, $0 < \Omega < 1$ and $c > t^*$ follow from (A2), Lemma 2 (i), a binding incentive constraint, and assumption 2, respectively. Moreover, the expression in the first line is negative too, because $\partial^2 k^*/\partial(\tau^*)^2 \geq 0$ (see (A2)), $\partial^2 t^*/\partial(\tau^*)^2 < 0$ (see (A3)), $0 < \Omega < 1$ (results again from binding incentive constraint), and $1 \geq (c-t^*)/(1-\Omega)^2$. The latter inequality can be derived by inserting (A12) into (A7): $dV/ds = 1 - (1-\Omega)^2/(c-t^*)$. 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 $dV/dm|_{m=m_2} > 0$, $dV/dm|_{m=\overline{w}-w_H+\widetilde{T}} < 0$, $d^2V/d(\tau^*)^2 < 0$, and $d\tau^*/dm > 0$ lead to an inverse u-shaped (or a bell-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: (i) Foreign net wage $\overline{w}$ only affects transfer b through its impact on τ^*. Since migration constraint (6) implies $d\tau^*/d\overline{w} = -\left(\partial T^*/\partial\tau^*\right)^{-1} < 0$, $dV/d\overline{w} = (dV/d\tau^*)(d\tau^*/d\overline{w}) \gtreqless 0 \Leftrightarrow dV/d\tau^* \lesseqgtr 0$, which in turn implies $dV/d\overline{w} \gtreqless 0$ if, and only if, $m \gtreqless m^{max}$.

Comparative statics shows

$$\frac{dm^{max}}{d\overline{w}} = -\frac{d^2V/\left(dm d\overline{w}\right)}{d^2V/d(m)^2} = -\frac{(d\tau^*/d\overline{w})}{(d\tau^*/dm)} = 1, \tag{A16}$$

since $d\tau^*/d\overline{w} = -\left(d\tau^*/dm\right) < 0$ (which is directly implied by migration constraint (6)).

(ii) For $m \in \left[m_2, \overline{w} - w_H + \widetilde{T}\right]$, the incentive constraint (11) is binding. Thus $dI_H/d\overline{w} \gtreqless 0 \Leftrightarrow dV/d\overline{w} \gtreqless 0$ (where $I_H := w_H - T^* + s^* - c$ stands again for the adjusted net income of skilled workers), implying $dI_H/d\overline{w} > (<) 0$ for $m \in (m^{max}, \overline{w} - w_H + \widetilde{T}]$ $(m \in (m_2, m^{max}))$. For $m \in [\overline{w} - w_H, m_1]$, $I_H = \overline{w} - m - c$ and $dI_H/d\overline{w} > 1$.

[14] Inserting (A12) into (A6, second line) yields $V = w_L + \Omega\left[1 - (c-t^*)/(1-\Omega)\right]$. This expression implies $dV/d\tau^* = -\partial k^*/\partial\tau^*\left[1-(c-t^*)/(1-\Omega)^2\right] + (\partial t^*/\partial\tau^*)\,\Omega/(1-\Omega)$, and enables us to calculate (A15) rather conveniently.

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Figure 1

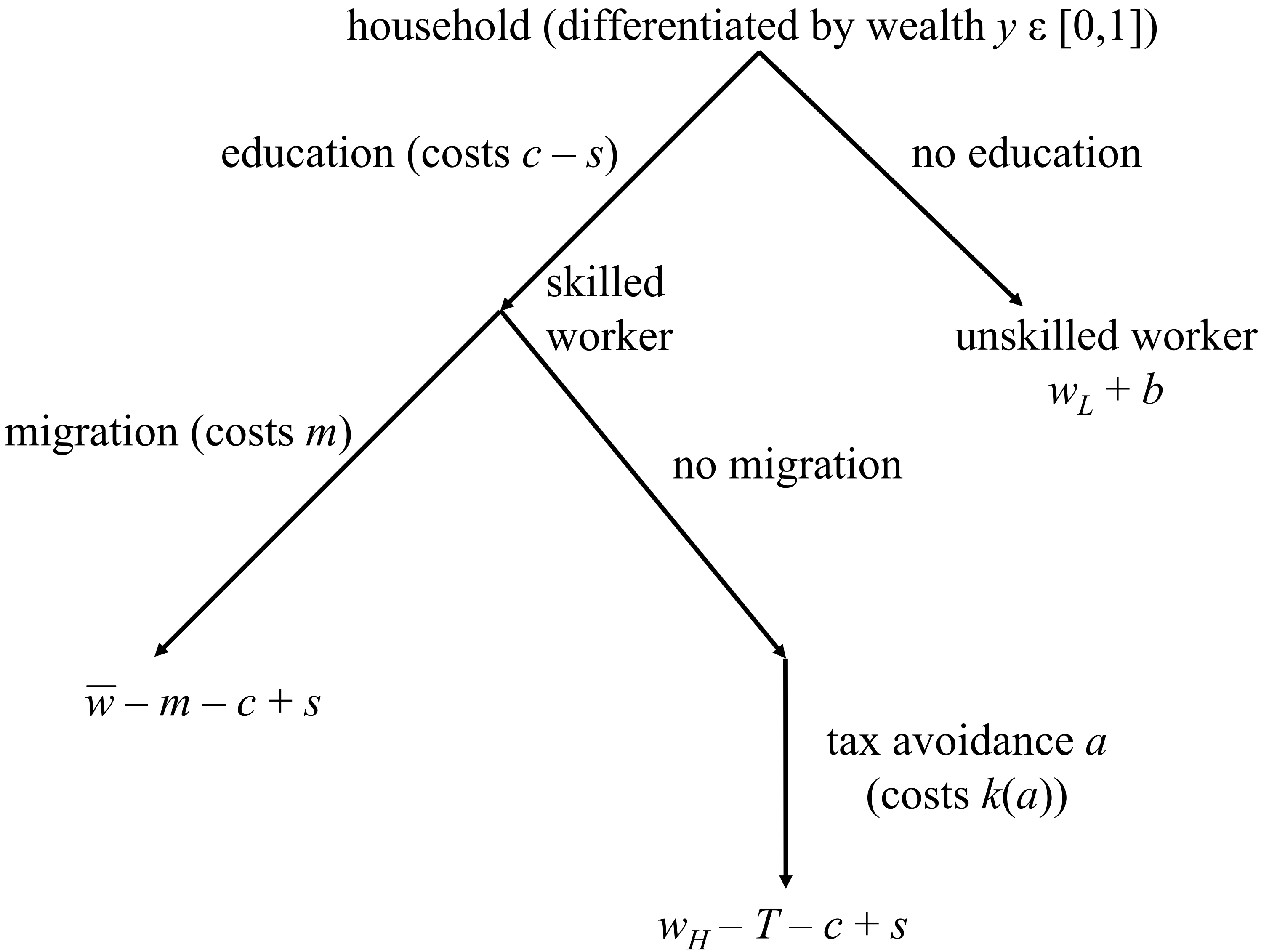

household (differentiated by wealth y ε [0,1])
education (costs $c - s$)
no education
skilled worker
unskilled worker
$w_L + b$
migration (costs m)
no migration
$\overline{w} - m - c + s$
tax avoidance a
(costs $k(a)$)
$w_H - T - c + s$

Figure 2

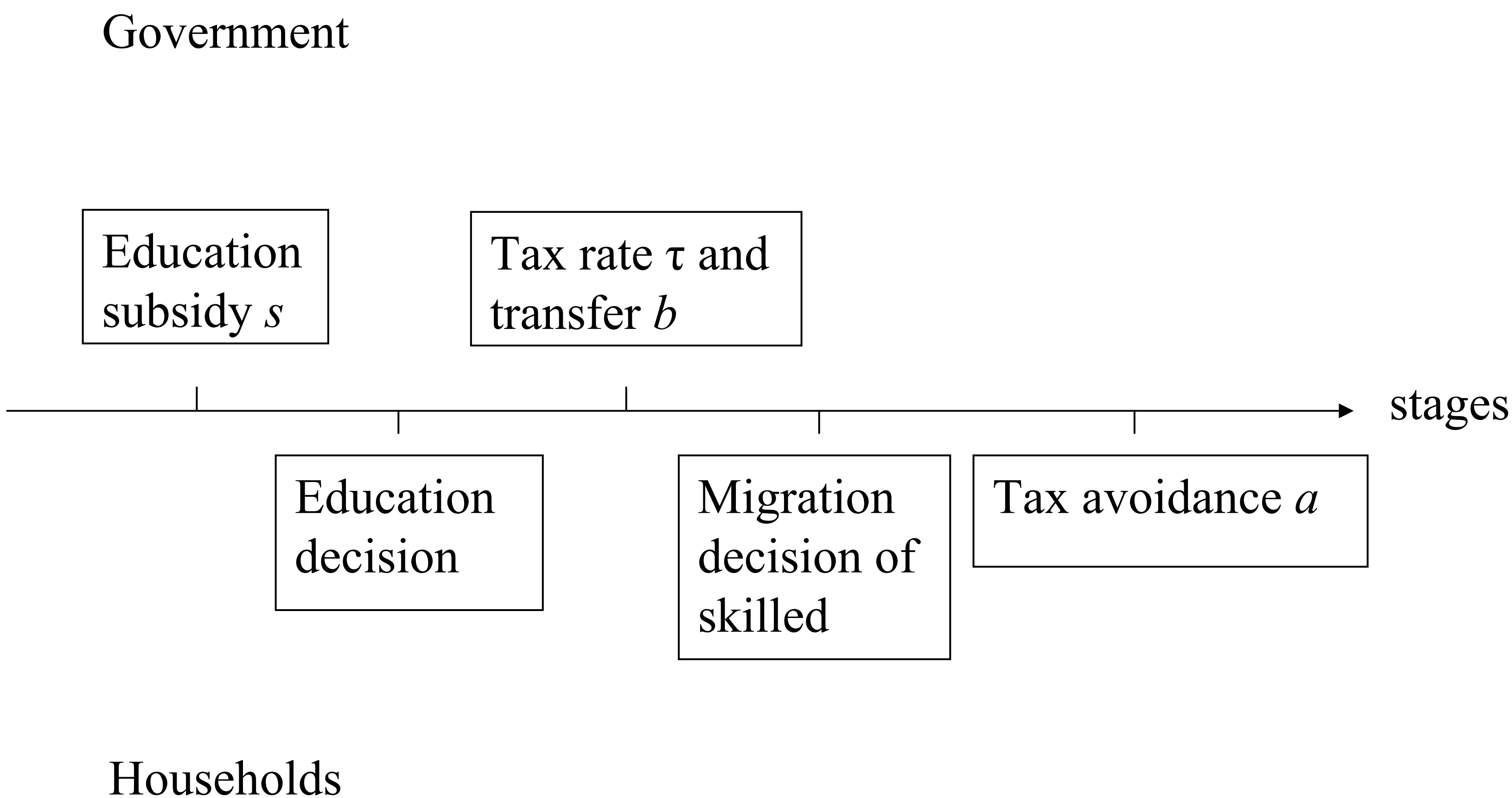
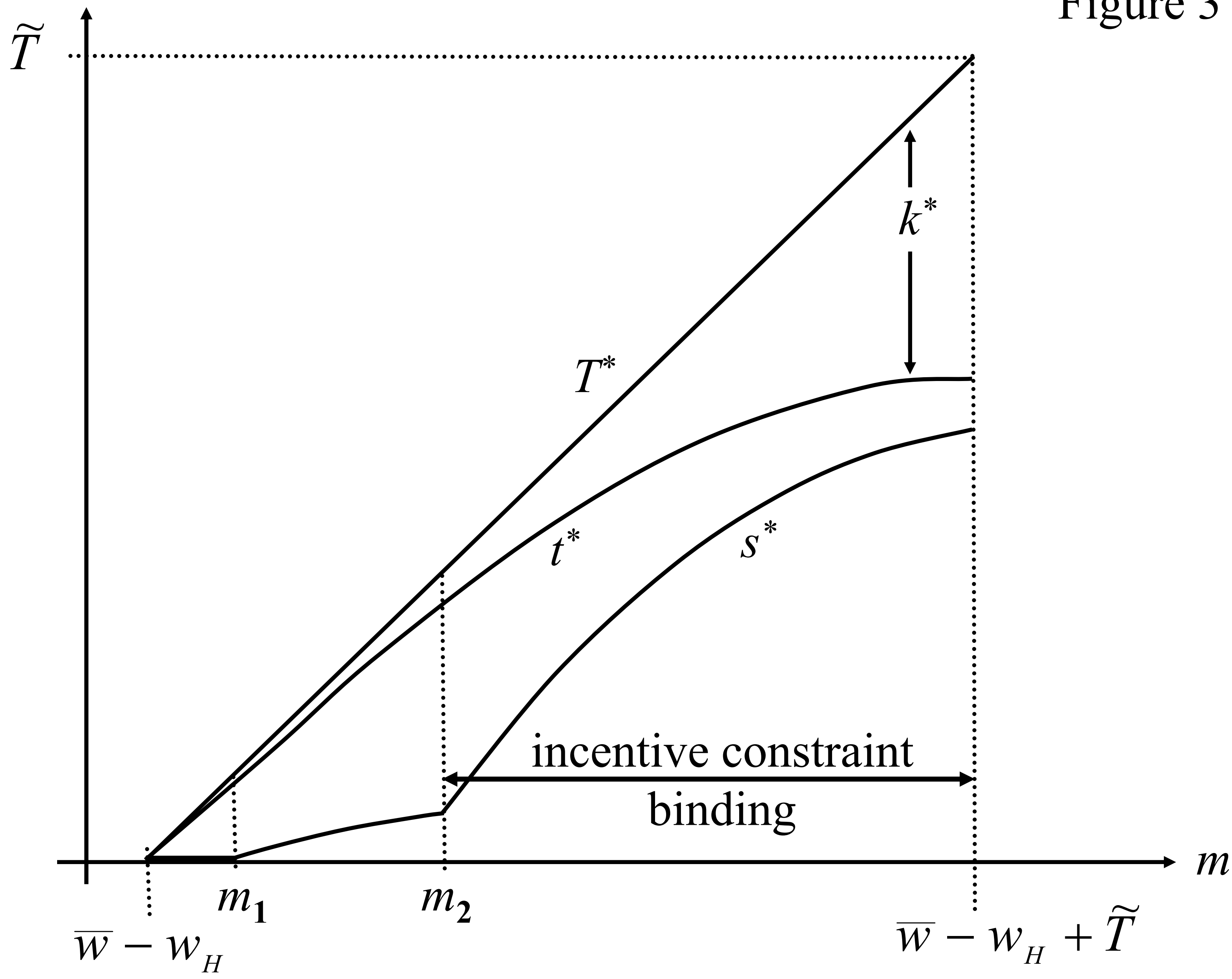
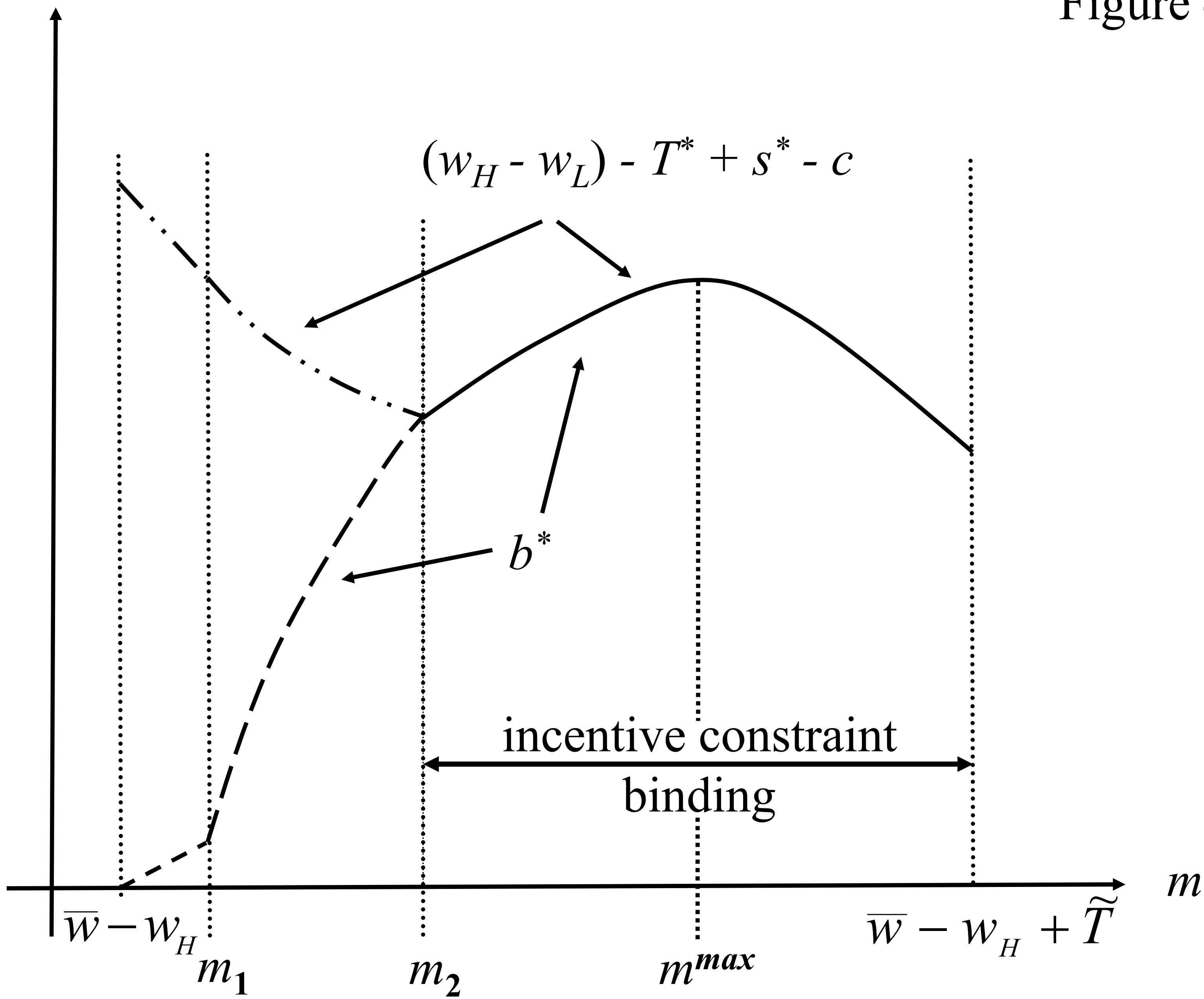

Government
Education subsidy s
Tax rate τ and transfer b
stages
Education decision
Migration decision of skilled
Tax avoidance a
Households

Figure 3



$\widetilde{T}$
k^*
T^*
t^*
s^*
incentive constraint binding
m
m_1
m_2
$\overline{w} - w_H$
$\overline{w} - w_H + \widetilde{T}$

Figure 4



$(w_H - w_L) - T^* + s^* - c$
b^*
incentive constraint binding
m
$\overline{w} - w_H$
m_1
m_2
m^{max}
$\overline{w} - w_H + \widetilde{T}$