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Keywords: Student mobility, worker mobility, university competition, governement competition

1 Introduction

In the last decade, student mobility has become an inescapable phenomenon, both for universities and policy makers. While for the year 2001, the world counted around 2 millions mobile students, this figure has increased up to 3.3 millions in 2009.[1] This phenomenon has increased competition between institutions of higher education, and has also important policy implications. Indeed, in the global economy, skilled labor has also become increasingly mobile, so that providers of higher education do not necessarily reap its benefits at the national level. This gives rise to a potential problem of free-riding from public entities providing funding to universities. A crucial question in

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[1]Organization for Economic Co-operation and Development (2010). Education at a Glance 2010. Paris: OECD

this context is that of the net impact of both student and worker mobility on university funding and higher education quality and research production.

This paper provides a normative analysis of endogenous student and worker mobility in the presence of diverging interests between universities and governments. Students are heterogenous in ability and in their benefits from studying abroad. Universities produce human capital and research, and compete in quality so as to attract students. Governments finance universities in order to maximize national output, based on research and skilled labor. In autarky, universities and governments have the same objective, which is to maximize a weighted sum of research and human capital. When student mobility is introduced, universities face a larger market and have incentives to raise their teaching quality. Another type of mobility to be accounted for in this context is that of workers. With the addition of worker mobility, the objectives of universities and governments diverge. Whereas the former focus the human capital they produce independently of where this human capital locates later, governments care about the stock of human capital which settles on their territory to contribute to the nation's economy. Therefore, worker mobility creates a free-riding effect for governments, which are not inclined to fund universities for offering teaching to students who will eventually leave the country.

We provide a theory of public funding of higher education institutions in the context of both student and worker mobility. In addition to this twofold mobility, our contribution explicitely accounts for the fact that governments and universities act as distinct agents pursuing their own and potentially conflictual objective. The motivation behind this approach is that the competition effect pertaining to student mobility directly affects universities' behavior, whereas worker mobility affects governments' incentives, yielding the free-rider effect. The former effect tends to increase the amount of resources that universities allocate to teaching, while the latter effect goes in opposite direction via a reduction of the funding per student received by universities. We show that the combination of government and university competitions produces a clear prediction about the net impact of student and worker mobility on the university's funding scheme. In the conxtext of fixed public budgets for higher education, this scheme, which consists in insufficient subsidies per student and excessive lumpsum subsidies to universities, incites universities to underprovide human capital and produce too much research compared to the socially desirable allocation. In other words, the free rider effect is shown to dominate the competition effect, at the expense of education quality. This adverse effect of worker mobility can be mitigated if a transnational entity could enforce transfers between government for mobile students. When taxes are introduced, worker mobility and public budgets become endogenous. In this case, policies aimed at raising teaching quality strenghten fiscal competition for skilled labor, reducing public budgets at the expense of research.

1.1 Mobility and the competition and free-riding effects

Two important and opposite effects of mobility on the incentives faced by higher education providers and governements are salient in the literature.

On the one hand, following the increase in student mobility, universities tend to engage in quality competition in order to attract mobile students. This effect is known as the competition effect and has been highlighted in a large variety of models in combination with admission standards (del Rey (2001)), tuition fees (Kemnitz (2005), Demange et al. (2008b), Lange (2009)) and multicultural skills (Mechtenberg & Strausz (2008)) among other.

On the other hand, worker mobility has adverse effects on the incentives of governments to subsidize higher education. Free-riding is widely acknowledged in this context (Justman & Thisse (1997); Justman & Thisse (2000); Poutvaara (2004); Kemnitz (2005); Chevalier & Gerard (2008); Demange et al. (2008b); Demange et al. (2008a); Mechtenberg & Strausz (2008); Lange (2009)).

Recent contributions have attempted to assess the combined impact of both the free-riding and the competition effects on higher education quality (Kemnitz (2005); Demange et al. (2008b); Mechtenberg & Strausz (2008); Lange (2009)). Demange et al. (2008b) highlight that, in a fiscal competition context, free-riding can be attributed to worker mobility while competition is driven by student mobility. In this sense, they argue that the Bologna process can help the latter effect to balance the former. The Bologna process is also an important motivation of Mechtenberg & Strausz (2008), which is one of the closest contribution to ours. In Mechtenberg & Strausz (2008), higher education is publicly provided, but unlike our model, the government directly makes the decision regarding the teaching quality offered. The extent of student mobility is defined by a threshold on the minimal ability of prospective students required to study abroad. The Bologna process for instance is considered to lower this threshold, increasing the potential number of mobile students. The government maximizes social welfare, accounting for externalities generated by foreign students who settle in the country as workers. The magnitude of this externality is the driving force determining the net effect in the tradeoff between competition and free-riding effects. When externalities from mobility are low, teaching quality is decreasing with mobility. In this case, free-riding dominates the competition effect and quality is suboptimal. With intermediate externalities, quality is non-monotonic in mobility and has an inverted-U shape: high mobility yields underinvestment, whereas low mobility yields overinvestment. Finally, with large externalities, the inverted-U shape remains, but overinvestment prevails, unless no mobility is permitted at all. The result that a higher mobility can weaken the competition effect and thereby reduce quality is somewhat counterintuitive. This result is due to what they call the composition effect, which stems from the assumption that increased mobility always comes at the cost of a lower average quality of students. This reduction in average ability in turn reduces the magnitude of the competition effect, leading to a decrease in quality. This assumption is not made in our model ; instead we assume that all students are capable of studying abroad, but only those with sufficient multicultural skills will do so.[2] Summing up, our model differs from that of Mechtenberg & Strausz (2008) in the following dimensions. We consider governments and universities as distinct entities, governments face a budget constraint (further with endogenous taxes, which also leads to endogeneous worker mobility), and universities produce both human capital and research. The first distinction between both models is already sufficient to produce a major difference in our results. Indeed, the fact that governments and universities are distinct entities, and that governements act as the principals of universities implies that the free-riding effect faced by governments always dominates the competition effect faced by universities.

Let us raise two additional points pertaining to mobility and education quality.

First, the education quality actually depends neither on student nor on worker mobility alone, but rather on the net flow between the two, namely the rate of return migration (Justman & Thisse (1997); Justman & Thisse (2000); Lange (2009); Demange & Fenge (2010)). More precisely, the rate of return migration is the main determinant of the magnitude of the free-riding effect (Justman & Thisse (1997); Justman & Thisse (2000)). As a correcting policy, some authors suggest to implement a system of monetary transfers between countries (or regions) depending either on migration flows (Justman & Thisse (1997); Justman & Thisse (2000)), or on student's mobility alone (Chevalier & Gerard (2008)). This paper gives new insights in this respect by providing a description of (1) how the public good characteristic of higher education depends on student and worker mobility flows and of (2) the way international transfers should depend on those two flows.

Second, there is often a tradeoff in the allocation of public funds between teaching and research. In the line of del Rey (2001), we analyze the impact of mobility both in terms of teaching and research under two alternative assumptions: first under exogenous budget and, second, under endogenous budget and tax competition.

Our model produces the following results. In autarky, given that the university and the government have the same objective, the university's teaching quality is efficient and is independent of the government's funding scheme. In the open economy with student and worker mobility, we distinguish several cases which we compare to the first best allocation. We first consider the case of a single supranational entity which would dictate the funding scheme of both universities, in order to focus on the university competition effect while preventing the governments' free-riding problem. The Nash equilibrium between universities shows that the teaching quality of one university is increasing in its own funding per student, and decreasing in that of the other university. The non-cooperative equilibrium reaches the first best allocation in this case since we show that the single public entity is able to design and implement an appropriate funding scheme to regulate competition. We then introduce government competition, and show that the free-rider effect

[2] While this does not qualitatively alter our results, this approach allows us to focus on the main driving forces at work in the context under study.

dominates the university competition effect. This results in underinvestment in teaching quality and overinvestment in research. This inefficiency can be solved if a supranational entity imposes a positive transfer between governments for each mobile student. Finally, worker mobility and government budgets are made endogenous by the introduction of a tax on skilled workers. The transnational transfer can maintain efficiency in education, but fiscal competition is strengthened by human capital production, which eventually threatens public budgets at the expense of research.

2 The model, the case of autarky

We start by introducing the simple case of autarky as a benchmark.[3] The country has a population of agents of unit size. Agents, who are unskilled, are heterogenous in ability $a \sim U[0,1]$. Ability is a complement of the education quality q provided by the university in the human capital production function. Incomes, which directly depend on the agent's level of human capital, are noted $y = aq$ after graduation, while unskilled wages are normalized to 0.[4] Higher education is supplied by a monopolistic public university and is free for students.[5] This university chooses the level of education quality q so as to maximize the following objective:[6]

$$U = H + \rho R,$$

where H and R are the stock of human capital produced and the amount of money devoted to research, respectively. The parameter ρ captures both the returns to the money invested in research and the university's marginal rate of substitution between human capital and research. The human capital produced by the university depends on the agents' decisions to enrol, and on the ability levels of those who choose to do so. The government provides the university with public funds, in the form of a fixed component G and a subsidy per student g. These subsidies must be such that the government's budget B is balanced:

$$B = G + ng, \tag{1}$$

where n is the number of students enrolled at university.[7] The university's research budget can then be written as

$$R = G + gn - T,$$

[3] We will then introduce a second country and student mobility in the next section.

[4] This set of assumptions has been used by many authors, including Mechtenberg & Strausz (2008).

[5] Along with the previous assumptions on ability and wages, free education implies that all agents are willing to enroll in university. This assumption could be relaxed to render the model more realistic by various means. For example, extending the support of a to negative values would imply that a fixed fraction of the population would never invest in higher education. Such a modification would not alter our results.

[6] We adopt the specification of del Rey (2001) which clearly highlights the tradeoff between teaching and research in the allocation of funds in a tractable way.

[7] In this basic version, B is fixed. We relax this assumption by introducing taxation in Section 3.5.

where T denotes the teaching costs which depend on the quality offered:

$$T = \frac{cq^2}{2}.$$[8,9]

The government's objective, Ω, is a function of research and the human capital which settles on its soil, noted W. In autarky, W is equivalent to H, the human capital produced by the university.[10]

$$\Omega = W + \rho R.$$

For simplicity and coherence, the weight parameter ρ is identical to that of the university.[11]

We start by analyzing the first best, and then analyze the non-cooperative allocation, which is characterized in autarky by a basic principal-agent model.

2.1 The first best

In the first best, the planner maximizes Ω with respect to q.

Proposition 1 *The first best allocation in autarky writes* $q^{FB} = \frac{1}{2\rho c}$.

Proof. Due to the teaching cost function and the distribution of student ability, full participation is socially optimal. As a result, human capital production as a function of q writes

$$W = \int_0^1 aqf(a)da = \frac{q}{2},$$

where the density of ability $f(a)$ equals 1 for $0 \leq a \leq 1$. The objective function therefore writes

$$\max_q \Omega = \frac{q}{2} + \rho \left(G + g - \frac{cq^2}{2} \right),$$

[8] This simple technology implies that teaching costs depend on the teaching quality independently of the number of students. Since teaching costs occur at the expense of research, it may be fair to consider these costs as time spent by academic staff not doing research. From this viewpoint, the time spent by the teacher to prepare courses in terms of content and pedagogy, the number of students in the classroom does not have such an important impact on teaching quality at university. Accounting for the number of students is feasible at the non cooperative equilibrium, but complicates considerably the first best analysis. Furthermore, it is clear from Mechtenberg & Strausz (2008) that convex quality costs are required to obtain interior solutions, whereas this is not the case with costs per students.

[9] The absence of costs per student, along with the distributional assumption on student ability implies that it is socially desirable that the whole population enrolls in university. Again, this assumption can easily be relaxed.

[10] This will cease to be the case in the open economy. Indeed, on the one hand, universities care about prestige, which is represented by the human capital they produce independently of where it will locate in the future. On the other hand, governments care about the human capital which will locate on their soil.

[11] One could argue that a natural objective for the government would be to maximize the national output strictly speaking. However, on the one hand, it is reasonable to assume that both research and aggregate human capital are factors of the production function of the national economy and so, this expression could be interpreted as a production function. On the other hand, since the aim of the paper is to highlight the impact of diverging interests between universities and governments, it is more convincing to use a specification as similar as possible between entities, with a single and plausible difference pertaining to human capital, either produced by the university, or settling on the government's soil.

he first best is characterized by the following first order condition:

$$\frac{\partial \Omega}{\partial q} = \frac{1}{2} - \rho c q = 0,$$

which implies

$$q^{FB} = \frac{1}{2\rho c}.$$

■

As previously mentioned, the fact the lower bound is zero only implies that the model focuses on potentially skilled agents, more precisely, agents for which it is socially desirable to invest in human capital. The model could easily allow for the presence of unskilled agents in the population, for example by extending the support of a to negative values.

2.2 The non-cooperative equilibrium

In the non-cooperative game, there are three types of players, namely the government, the university and the agents, who play sequentially. The timing of the game is the following. First, the government defines a funding scheme (G, g) for the university. Second, the university sets a teaching quality q. Third, unskilled agents choose to study or not.

Proposition 2 *In autarky, the non-cooperative allocation is the same as the first best and is independent of the government's behavior.*

Proof. We solve the game by backward induction.
We therefore analyze unskilled agents' decisions to enrol at university or not. Agents decide to enroll if $aq > 0$, which is the case for all agents. In this simple version of the model, the whole population is willing to enroll at university $(n = 1)$.[12] The stock of human capital produced by the university depends on quality q and writes

$$H = \int_0^1 (aq) f(a) \, da = \frac{q}{2}.$$

The objective function therefore writes

$$\max_q U = \frac{q}{2} + \rho \left(G + g - \frac{cq^2}{2} \right),$$

and the first order condition with respect to quality gives the university's optimal education quality:

$$q^* = \frac{1}{2\rho c} = q^{FB}. \tag{2}$$

■

[12] As already mentioned, this simplification can easily be relaxed to allow for the existence of unskilled agents in the population. Also note that while the number of skilled agents is fixed, their level of human capital is endogenous.

In this basic framework, given that the university and the government have the same objective, and that education investments are efficient for all agents, the university's optimal q is the same as the first best level and is independent of the government's funding scheme $\{G, g\}$. Education quality q^* is decreasing in the cost parameter c and in the preference for research ρ, as expected.

Let us now study the case of the open economy, which implies student and worker mobility. The consequences of mobility on the non-cooperative equilibrium are twofold. On the one hand, the level of competition for attracting students increases. National universities become competitors in a larger market for higher education. On the other hand, governments of different countries are now involved in the definition of education policies. More precisely, under mobility and competition, universities' strategies are now affected by both governments' education policies, which also entails a free rider problem.

3 The open economy

Student mobility provides a potential premium to the standard human capital aq. Studying abroad also entails costs in terms of adaptation and language learning efforts, and these costs are likely to be unevenly distributed in the population. We define a net mobility premium $\mu \sim U\left[-\left(1-m\right)s_\mu, ms_\mu\right]$ obtained by mobile students, which is assumed independent of ability a.[13] Even if the mobility gain can be assumed to be strictly positive and constant across the whole population, it is outweighed by the cost of effort for a fraction $(1-m)$ of the population. Under these distributional assumptions, the joint density of an individual of abilty a and mobility premium μ writes $h\left(\mu, a\right) = \frac{1}{s_\mu} \equiv h$, where s_μ defines the length of the support of the marginal distribution of μ. As will be shown below, the level of competition between universities is increasing in the marginal number of students they can attract by raising quality. As a result, the intensity of university competition is a decreasing function of s_μ.

We assume two countries $\{1, 2\}$ of identical population compositions in terms of a and μ and identical unit sizes.

3.1 The first best

In the open economy, the social planner seeks to maximize $\Omega_1 + \Omega_2$ and makes use of teaching qualities q_1 and q_2 and selects the agents who will become skilled, and more precisely, those who will stay in their origin country and those who will study abroad and benefit from the mobility premium.[14] For that matter, we define $\widetilde{\mu}_i\left(a; q_i, q_j\right)$ as the minimal mobility premium required for

[13] This parameter corresponds to the concept of multicultural skills that appears in Mechtenberg & Strausz (2008). In our model, however, this parameter enters the income function additively rather than multiplicatively.

[14] Note that at the first best allocation, the location of skilled workers is irrelevant since the planner cares about the total stock of human capital formed independently of its location. Worker mobility will be specified in the non-

an agent from country i with ability a to be sent to study in university j.

Proposition 3 *The first best allocation in the open economy is symmetric and writes* $\left(q^{FB}, \widetilde{\mu}^{FB}\right) = \left(\frac{1}{2\rho c}, 0\right)$.

Proof. Let us start by looking at the first order condition with respect to teaching quality q_i:

$$\frac{\partial\left(\Omega_1+\Omega_2\right)}{\partial q_i}=\frac{\partial\left(W_1+W_2\right)}{\partial q_i}-\rho c q_i=0,$$

where $W_1+W_2=H_1+H_2$ is the total stock of human capital produced in both countries. Let us assume for a moment that the selection of students is the same in both countries. Then, since technologies and population composition of both countries are identical, the marginal benefit $\frac{\partial(W_1+W_2)}{\partial q_i}$ is the same in both countries, so that marginal costs should be equalized, which implies that $q_1^{FB}=q_2^{FB}$. Let us now analyze the selection of students. As in the case of autarky, it is socially desirable that all students enroll in university. However, it may be preferable to educate some agents in the foreign country. This will be the case for those such that $aq_j^{FB}+\mu>aq_i^{FB}$, that is $\mu>a\left(q_i^{FB}-q_j^{FB}\right)$. This implies that if $q_i^{FB}=q_j^{FB}$, the minimal mobility premium to be sent in the foreign university is $\widetilde{\mu}_1^{FB}=\widetilde{\mu}_2^{FB}=0$. Summing up, posing identical student selection implies identical teaching quality q^{FB} in both countries, and in turn, identical teaching quality implies identical student selection for both countries. In other words, we have just shown that a symmetric first best allocation exists, with $\widetilde{\mu}^{FB}=0$. It just remains to show which is the optimal level of teaching quality q^{FB}. Using symmetry, the planner's objective writes

$$\Omega_1+\Omega_2=2\left(W+\rho R\right),$$

where, substituting for optimal student selection,

$$\begin{aligned} W &= \int_0^1\int_{-(1-m)s_\mu}^0 (aq)\,h(\mu,a)\,d\mu da+\int_0^1\int_0^{ms_\mu}(aq+\mu)\,h(\mu,a)\,d\mu da \\ &= \frac{q+s_\mu m^2}{2}. \end{aligned}$$

The first best level of q is therefore such that

$$\frac{1}{2}-\rho q^{FB}c=0,$$

that is,

$$q^{FB}=\frac{1}{2\rho c}.$$

Research therefore writes

$$R^{FB}=B-\frac{1}{8c\rho^2}.$$

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cooperative game with two governements.

■

Let us now turn to the non-cooperative analysis, which we decompose into two parts, one with a single government in order to isolate the competition effect of universities, and one with two governments, which adds the free-rider problem between the latter.

3.2 The non-cooperative game with a single government

This subsection can be considered as the case of a single governmental entity, such as the European Commission, defining the same public finance policy to all its member states' universities. There are therefore three types of players, namely the governmental entity, the two universities and the agents of both countries. The timing of the non-cooperative game is the following. First, the public decision-maker defines the funding schemes $\{G_1, g_1, G_2, g_2\}$. Second, universities of country 1 and 2 simultaneously and non-cooperatively choose their level of education quality q_1 and q_2 respectively. Third, students from each country choose an education quality, and therefore select a location for their studies.[15]

Proposition 4 *The non cooperative equilibrium with a single government reaches the first best allocation. Student mobility creates a positive competition effect in terms of teaching quality. The Nash equilibrium between universities shows that the teaching quality of one university is increasing in its own funding per student, and decreasing in that of the other university.*

Proof. We solve the model backwards. At the last stage of the game, agents have to decide where to study. An agent from country i has income y_{ii} if he/she studies in i and y_{ij} if he/she studies in j, where

$$\begin{aligned} y_{ii} &= aq_i \\ y_{ij} &= aq_j + \mu. \end{aligned}$$

The decision to study abroad is therefore taken if and only if the mobility premium is large enough:

$$y_{ij} > y_{ii} \iff \mu > \mu_{ij} \equiv (q_i - q_j)\, a. \tag{3}$$

In other words, μ_{ij} is the minimal mobility premium of agents from country i who decide to study in university j.

Let us now analyze the stage of university competition. In order to address the question of how universities compete, let us first describe how teaching qualities of both countries q_1 and q_2 affect the demand for education in each country. From the students' rule of location decision shown in

[15] Note that, as in the first best analysis, the location of skilled workers is irrelevant for a single government. In order to simplify the presentation, worker mobility will be specified in the non-cooperative game with two governements.

(3), we can write the number of agents from i studying in their origin country, n_{ii}, and the number of agents from i studying in j (n_{ij}):

$$\begin{aligned} n_{ij} &= \int_0^1 \int_{\mu_{ij}}^{s_\mu m} h(\mu, a)\, d\mu da \\ &= m + \frac{1}{2s_\mu}(q_j - q_i) \\ n_{ii} &= 1 - m - \frac{1}{2s_\mu}(q_j - q_i). \end{aligned}$$

The total number of agents studying in university i is therefore

$$n_i = n_{ii} + n_{ji} = 1 + \frac{1}{s_\mu}(q_i - q_j). \tag{4}$$

Quite intuitively, the demand for education in university i is increasing in the latter's quality, and decreasing in university j's quality. It can also be noted that $1/s_\mu$ measures the constant slope of n_i with respect to q_i. The lower s_μ, the higher the sensitivity of demand with respect to the quality differential. A low s_μ corresponds to a high value for the density of μ, meaning that, if university i raises quality at the margin, it attracts a larger mass of additional students. It follows that s_μ is inversely related to the competition level.

Using similar index notations, the aggregate stock of human capital produced by university i is noted:

$$H_i = H_{ii} + H_{ji},$$

where the human capital created with the local students, H_{ii}, is

$$H_{ii} = \int_0^1 \int_{-(1-m)s_\mu}^{\mu_{ij}} (aq_i)\, h(\mu, a)\, d\mu da = q_i \left(\frac{q_i - q_j}{3s_\mu} + \frac{1-m}{2} \right).$$

The stock of human capital created with mobile students takes account of the mobility premium. The human capital produced with agents coming from j to study in university i is noted H_{ji}:

$$H_{ji} = \int_0^1 \int_{\mu_{ji}}^{ms_\mu} \frac{(aq_i + \mu)}{s_\mu} d\mu da = \frac{s_\mu m^2}{2} + \frac{mq_i}{2} + \frac{q_i^2 - q_j^2}{6s_\mu}.$$

Therefore, the aggregate stock of human capital produced by university i is

$$H_i = \frac{q_i^2}{2s_\mu} + \frac{q_i}{2} - \frac{q_i q_j}{3s_\mu} - \frac{q_j^2}{6s_\mu} + \frac{s_\mu m^2}{2}. \tag{5}$$

Making use of (4) and (5), the objective of the universities is given by

$$U_i = H_i + \rho \left(G_i + g_i n_i - \frac{cq_i^2}{2} \right).$$

University i maximizes U_i with respect to q_i, considering university j's strategy as given. University i's reaction function writes

$$q_i^* (q_j; g_i) = \frac{\rho g_i - q_j/3 + s_\mu/2}{s_\mu \rho c - 1}. \tag{6}$$

Education qualities chosen by the universities are strategic substitutes if and only if $s_\mu \rho c > 1$. This condition is precisely the condition under which the maximization problem of the university is well-behaved. Indeed, considering q_j as given, the university's objective is concave if and only if

$$\frac{\partial^2 U_i}{\partial q_i^2} = \frac{\partial^2 H_i}{\partial q_i^2} + \rho \frac{\partial^2 R_i}{\partial q_i^2} = \frac{1}{s_\mu} - \rho c < 0.$$

The cost of quality decreases the amount of money invested in research. This cost is convex. However, the introduction of competition for students makes H_i, the stock of human capital produced by university i, also convex in q_i. Indeed, while the stock mechanically increases with h_i, a higher quality level also attracts additional students under student mobility. The combination of these two effects generates a convex gain. The above mentioned condition ensures that the cost side increases in h faster than the gain side. It is satisfied as soon as the cost parameter c and/or the preference for research ρ are high enough, or if $\frac{1}{s_\mu}$ is low enough. This last condition is due to the following mechanism. The second derivative of H_i with respect to q_i is precisely $\frac{1}{s_\mu}$, which is the joint density $h(a, \mu)$, and is also equal to $\frac{\partial n_i}{\partial q_i}$, the marginal number of students a university can attract by raising its quality. If $\frac{1}{s_\mu}$ is low, this means that the benefits from competition are limited, so that costs from competition will grow faster than its benefits. We assume that this condition, which only relies on parameters, is satisfied.

Combining both universities' reaction functions, one obtains the Nash equilibrium between universities:

$$q_i^N (g_i, g_j) = \Phi \left(\alpha g_i - (\alpha - 1) g_j + \frac{s_\mu}{2\rho} \right), \tag{7}$$

where

$$\begin{aligned} \Phi &= \frac{\rho}{s_\mu \rho c - \frac{2}{3}}, \\ \alpha &= \frac{s_\mu \rho c - 1}{s_\mu \rho c - \frac{4}{3}}. \end{aligned}$$

In order to assess the effect of the funding per student of both governments g_i and g_j, let us analyze Φ and α. Since we assumed that $s_\mu \rho c > 1$ (otherwise the best response functions we formulated in the quality game would not be valid), we know that $\Phi > 0$. It is straightforward to show that $\alpha < 0$ for $1 < s_\mu \rho c < \frac{4}{3}$ and $\alpha > 1$ for $s_\mu \rho c > \frac{4}{3}$. Therefore, we face here two distinct cases. The first one, in which $s_\mu \rho c > \frac{4}{3}$ is quite natural and intuitive. Indeed, in this case, the quality offered by university i is increasing in the funding per student it receives from its government ($\frac{\partial q_i^N}{\partial g_i} = \Phi \alpha > 0$), whereas this quality is decreasing in the funding per student that its competitor receives ($\frac{\partial q_i^N}{\partial g_j} = -(\alpha - 1) \Phi < 0$). The second case ($1 < s_\mu \rho c < \frac{4}{3}$) is clearly less intutitive, since the effects of subsidies are reversed: the quality offered by university i is decreasing in the funding per student it receives from its government, whereas this quality is increasing in the funding per student that its competitor receives: $\frac{\partial q_i^N}{\partial g_i} = \Phi \alpha < 0$ and $\frac{\partial q_i^N}{\partial g_j} = -(\alpha - 1) \Phi > 0$.

These two different cases have naturally different repercussions on the optimization problem of the governement. We are going to see indeed that the government can only reach an interior solution in its funding policy in the first case, where $s_\mu \rho c > \frac{4}{3}$.

Let us therefore analyze the government/social planner's behavior. In particular, the question we address here is whether a government/principal facing two universities/agents is able to provide them with the right incentives so as to obtain the first best allocation. The objective of the social planner depends on the aggregate stock of human capital and on the aggregate research budget:

$$\Omega = U_1 + U_2 = W_1 + W_2 + \rho \left(R_1 + R_2 \right), \tag{8}$$

where $W_1 + W_2 = H_1 + H_2$, which are obtained from the combination of (5) and (7). Also, using (4) and (7), and the government's budget constraint (1),

$$R_1 + R_2 = 2B - \frac{c}{2} \left(q_1^2 + q_2^2 \right).$$

Maximizing (8) with respect to g_1 and g_2 implies

$$\frac{d\Omega}{dg_i} = \frac{\partial \Omega}{\partial q_i} \frac{\partial q_i}{\partial g_i} + \frac{\partial \Omega}{\partial q_j} \frac{\partial q_j}{\partial g_i} = 0,$$

under the following second order condition:

$$\frac{\partial^2 \Omega}{\partial g_i^2} = - \frac{3\rho^2 \left(\left(3c\rho s_\mu \right)^2 - 12 c\rho s_\mu + 2 \right)}{s_\mu \left(3c\rho s_\mu - 2 \right)^2 \left(3c\rho s_\mu - 4 \right)}.$$

Before interpreting the first order condition, let us discuss the second order condition, which is basically on condition on $c\rho s_\mu$. Under the set of relevant values of $c\rho s_\mu$ for an the interior solution of the quality game under consideration here (that is, $c\rho s_\mu > 1$), the second order condition is not satisfied in the interval $]1.138; 4/3[$, and is satisfied everywhere else.[16] We therefore focus on the first case described above ($c\rho s_\mu > 4/3$), which is both intuitive in terms of the impacts of subsidies on the Nash equilibrium qualities and also validates the second order condition of universities.

Going back to the first order condition, it yields the following interior subsidy policies:

$$\begin{aligned} g_i^* &= g_j^* = -\frac{1}{3\rho^2 c} \\ G_i^* &= G_j^* = B + \frac{1}{3\rho^2 c}. \end{aligned}$$

Plugging this level of g into the non-cooperative level of teaching quality, one obtains the first best level:

$$q_i^N \left(g_i^*, g_j^* \right) = \frac{1}{2\rho c} = q^{FB}. \tag{9}$$

[16] The value of 1.138 was chosen for expository reasons, and is an approximation of the actual root $\frac{1}{3}\sqrt{2} + \frac{2}{3}$.

■

Since university competition creates an incentive for universities to raise teaching quality to attract students, and since the higher the subsidies, the larger this incentive, the government must offer a large fixed subsidy G and "tax" universities for their students ($g^* < 0$). This result of a negative per student subsidy may seem, at first sight, unrealistic. It can be understood in the light of two arguments. First, teaching costs are assumed independent of the number of students. If costs were affected by the number of students, the overinvestment problem would be less important, and governments should also contribute to these costs through g. Second, we have assumed that the parameter ρ was identical between governments and universities. It could be realistic to assume that universities are more oriented towards research, in which case $\rho_U > \rho_G$. Under this alternative assumption, the teaching activity is essentially a way for universities to collect public funds to finance research. It follows that, in order to provide universities with incentives to offer education quality thereby producing the desirable stock of human capital, the government has to subsidize students. More precisely, one can show that under the more general case where ρ_U and ρ_G are distinguished,

$$\begin{aligned} g_i^* &= \frac{3cs_\mu\left(\rho_U - \rho_G\right) - 2}{6c\rho\rho_G} \\ &> 0 \Leftrightarrow \rho_U > \rho_G + \frac{2}{3cs_\mu}. \end{aligned}$$

3.3 The non-cooperative game with two governments

This subsection introduces the game between governments. An important feature of the case with two governments is the workers' location decision. Indeed, governments are interested in the stock of human capital that eventually works on its soil. Let $\omega \sim U\left[-\left(1-o\right);o\right]$ represent the agents' preferences for living/working in their country of origin. This means that ceteris paribus, a fraction o of the population prefers to settle in its country of origin. These preferences are independent of ability and mobility premia.[17] The timing of the non-cooperative game is the same as in the previous subsection, except for two things. First, in the first period, two governments are competing. Second, the game has one more period, in which the skilled agent chooses his location decision.

Proposition 5 *The non cooperative game with two governments results in underinvestment in teaching quality and suboptimal human capital production. The positive university competition effect is dominated by the government free-rider effect. The degree of inefficiency of the non-cooperative equilibrium is increasing in the number of agents who leave the country in which they studied.*

Proof. We solve the model backwards. At the last stage of the game, agents have to decide where to work. Since at this stage, incomes are given and depend only on the human capital acquired and

[17] This extremely simple modeling strategy will be enriched in subsection 3.5 when taxes will be introduced, so that worker mobility and the government's budget will be made endogenous.

not on the work location, an agent will choose to work in his/her country of origin if $y+\omega > y$, that is, $\omega > 0$. The proportion of agents working in their country of origin is therefore o. It follows from the assumption of independence that such a proportion applies to every ability level and wherever the agents studied.

The next two stages to be studied are that of student participation and mobility choices and that of university competition. The analysis of these two stages is identical to the previous subsection. We can therefore focus on the government game. Each government implements non-cooperatively its funding scheme $\{G_i, g_i\}$ so as to maximize the production of its own economy,

$$\Omega_i = W_i + \rho R_i,$$

where, taking account of worker mobility,

$$W_i = o\left(H_{ii} + H_{ij}\right) + (1-o)\left(H_{jj} + H_{ji}\right),$$

and, taking account of the budget constraint,

$$R_i = B - \frac{cq_i^2}{2}.$$

Each government's reaction function therefore writes[18]

$$\begin{aligned} \frac{\partial \Omega_i}{\partial g_i} &= \frac{\partial W_i}{\partial q_i}\frac{\partial q_i^N}{\partial g_i} + \frac{\partial W_i}{\partial q_j}\frac{\partial q_j^N}{\partial g_i} + \rho\frac{\partial R_i}{\partial q_i}\frac{\partial q_i^N}{\partial g_i} = 0 \\ \Longleftrightarrow \quad & \frac{\partial W_i}{\partial q_i}\alpha - \frac{\partial W_i}{\partial q_j}(\alpha - 1) = \rho c q_i \alpha. \end{aligned}$$

The previous equation shows that government i equalizes the marginal benefits of g_i to its marginal cost. The marginal benefits of g_i are twofold. On the one hand, it creates an incentive for university i to raise its teaching quality, and therefore W_i, and on the other hand, it deters university j from investing in q_j^N, which also increases W_i. Combining both governments' reaction function, one obtains the following Nash equilibrium:

$$g_i^N = g_j^N = \frac{\Theta}{2\Phi\alpha\rho c} - \frac{(1-2m)\left(2(1-o)-1\right)}{2\Phi\rho c} - \frac{s_\mu}{2\rho},$$

where

$$\begin{aligned} \Theta &= 2(1-o)(1-m) + o - (1-m) \\ &\in [0;1]. \end{aligned} \tag{10}$$

Plugging this expression into the Nash equilibrium of universities' teaching quality, one obtains

$$q_i^N\left(g_i^N, g_j^N\right) = q_j^N\left(g_i^N, g_j^N\right) = \frac{1}{2\rho c} - \frac{\left(s_\mu \rho c - 2/3\right)\Theta}{2\rho c\left(s_\mu \rho c - 1\right)}.$$

[18]It can be shown that the government's second order condition is satisfied if and only if $s_\mu \rho c > 4/3$.

This expression implies that, with two governments, the non-cooperative equilibrium level of teaching quality is suboptimal. Indeed, $q_i^N\left(g_i^N, g_j^N\right) \leq q_i^{FB} = \frac{1}{2\rho c}$ since $s_\mu \rho c > 4/3$ and $\Theta \geq 0$. ■

The inefficiency of the non-cooperative allocation captured by Θ is represented graphically in the three-dimensional space with horizontal axes (o, m) in the following figure: There are two limit

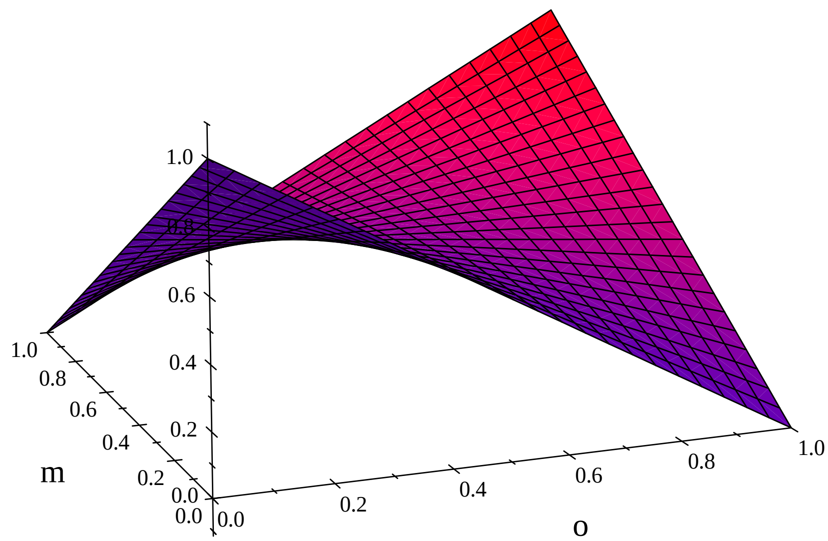

Figure 1: Inefficiency of the non cooperative solution as a function of o and m.

cases where the non-cooperative outcome is efficient, which are $\{o = 0, m = 1\}$ and $\{o = 1, m = 0\}$. The first case is such that all agents study abroad (since they all have positive mobility premia) and prefer to live and work in the foreign country as well (since $o = 0$). The second case can be seen as autarky, in which all agents study in their country of origin and prefer to live and work in their country of origin as well. In both cases, there is no problem of governments free-riding on public goods since the population of agents studying in one country is the same as the population working in this same country. The other two extreme cases, where the inefficiency is maximal, are either when all agents have positive mobility premia but prefer to work in their origin country, or when all agents have negative mobility premia but prefer to work abroad. In these two cases, the government's free-riding problem is maximal, since all agents studying in country i go to work in country j. The degree of inefficiency of the non-cooperative outcome is in fact embodied in Θ defined in equation (10). More precisely, Θ represents the extent to which the higher education problem has public good characteristics. The following section shows that the correcting public policy is more subtle than usually acknowledged.

3.4 University and government competition with a regulator

In this subsection, a supranational authority imposes transfers between governments for the funding of mobile students. Indeed, up to now, local governments were financing the studies of foreign students. The question we address in this subsection is whether a transfer between governments per mobile student can lead to the first best allocation. For that matter, we introduce an additional player, called the supranational authority, who plays before governments and imposes government j to make a transfer b to government i for each student originating from j who studies in i.

The only remarkable change in the subsequent periods pertains to government i's budget constraint, which now writes

$$B + (n_{ji} - n_{ij})\, b = G_i + n_i g_i,$$

where the budget is made endogenous by the addition of a second term which measures the aggregate monetary flow from country j to country i. Since all subsequent stages of the game are unchanged, we study the government game while taking this modification into account. The Nash equilibrium between the two governments becomes in this case:

$$\begin{aligned} g_i^{Nb} &= g_j^{Nb} = \frac{(s_\mu \rho c - 2/3)^2}{s_\mu \rho c\,(s_\mu \rho c - 1)} b + \frac{\Theta - \alpha\,(2\,(1-m)-1)\,(2\,(1-o)-1)}{2\Phi\alpha\rho c} - \frac{s_\mu}{2\rho} \\ &= g_i^N + \frac{(s_\mu \rho c - 2/3)^2}{s_\mu \rho c\,(s_\mu \rho c - 1)} b. \end{aligned}$$

The transfer between governments creates an incentive for governments to raise funding per student and therefore teaching quality of their university. The supranational authority can therefore set a level of b such that $q_i^N\left(g_i^{Nb}, g_j^{Nb}\right) = q_i^{FB}$, where

$$q_i^N\left(g_i^{Nb}, g_j^{Nb}\right) = \frac{1}{2\rho c} - \frac{(3 s_\mu \rho c - 2)\,(2\rho b - \Theta s_\mu)}{6 s_\mu \rho c\,(s_\mu \rho c - 1)}.$$

This implies that the optimal transnational transfer equals

$$b^* = \frac{s_\mu}{2\rho}\Theta \geq 0.$$

The optimal transnational transfer is increasing in Θ, reflecting the fact that, the more the problem looks like a public good setting, the more the origin country has to support the costs of its mobile students. An important result is that this function is continuous. In other words, the correcting public policy has to be adapted to the degree of mobility of both students and workers, indicating that the supranational entity may have to collect information about mobility before implementing a potential intervention. For instance, an excessive level of the transnational transfer would yield overinvestment in teaching quality at equilibrium.

3.5 Endogenizing worker mobility and government budgets with fiscal competition

In this final subsection, governments have a second decision variable in the first stage. Not only do they define the funding policy of universities, but they also set the tax levels they impose on the workers who settle on their soil. This additional decision variable considerably enriches the model by adding two crucial features. First, this fiscal competition is aimed at attracting skilled labor, making worker mobility endogenous. Second, taxes make the government's budget endogenous, which implies that governments willing to attract more skilled labor face the risk of lowering their fiscal revenues, which will impact university funding. Formally, the government game therefore becomes a simultaneous game in which both players have two decision variables, namely g_i and t_i.

As will be shown further, the government's budget and objective will be affected by this change. Indeed, this objective depends on the human capital working on its soil, and worker mobility is affected by taxation. To see this, let us analyze the last stage of the game. At this stage, incomes are given and depend only on the human capital acquired and not on the work location, an agent will choose to work in his/her country of origin if $y - t_i + \omega > y - t_j$, that is, $\omega > t_i - t_j$. The proportion of agents working in their country of origin is therefore

$$p_i = o - t_i + t_j.$$

As in the previous sections, this proportion applies to every ability level and wherever the agents studied. Therefore, the next two stages to be studied (student location and university competition) are not affected by this. We can therefore focus on the government game. Each government implements non-cooperatively its funding scheme and its taxation scheme $\{G_i, g_i, t_i\}$ so as to maximize the production of its own economy,

$$\Omega_i = W_i + \rho R_i,$$

where, taking account of worker mobility,

$$W_i = p_i \left(H_{ii} + H_{ij}\right) + \left(1 - p_i\right)\left(H_{jj} + H_{ji}\right),$$

and, taking account of the budget constraint,

$$R_i = B + \left(n_{ji} - n_{ij}\right) b + \left(p_i + 1 - p_j\right) t_i - \frac{cq_i^2}{2}.$$

Each government has two reaction functions, which are determined by $\frac{\partial \Omega_i}{\partial g_i} = 0$ and $\frac{\partial \Omega_i}{\partial t_i} = 0$. It can be shown that the combination of both governments' reaction functions with respect to t_i and t_j implies that

$$t_i^N = t_j^N = \frac{1}{2} - \frac{1}{2\rho}\left(\frac{\Phi^2 \left(g_i - g_j\right)^2 \left(2\alpha - 1\right)^2}{3 s_\mu} + s_\mu m^2 + \frac{\Phi\left(s_\mu + \rho\left(g_i + g_j\right)\right)}{2\rho}\right).$$

This symmetry result in terms of taxation is very important because the rest of the problem now boils down to the problem with exogenous taxation. Indeed, we have that $p_i = o$ as under exogenous worker mobility, and the budget is back to the form derived in subsection 3.4. The combination of the governments' reaction functions with respect to g_i and g_j therefore yields the same results as before. In other words, tax competition and endogenous worker mobility do not mitigate nor aggravate the free-riding problem of governments.

Using the symmetry $g_i^{Nb} = g_j^{Nb}$, taxes at equilibrium are:

$$t_i^N = t_j^N = -\frac{\Phi\left(\frac{s_\mu}{2\rho} + g^{Nb}\right) + s_\mu m^2 - \rho}{2\rho}$$

Making use of g^{Nb} and b^*, one obtains that

$$t_i^N = t_j^N = 1/2 - \frac{H^{FB}}{\rho},$$

where H^{FB} is the stock of human capital produced in one country at the first best:

$$H^{FB} = \frac{1}{2}\left(\frac{1}{2\rho c} + s_\mu m^2\right).$$

Note that equilibrium taxes are decreasing in H^{FB}/ρ. In other words, fiscal competition is more likely to be fierce if skilled labor is too valuable relative to research, which gives governments an incentive to attract skilled workers at the expense of research. This will be the case if mobility premia are frequent (m large), costs of producing human capital (c) are low, and the relative productivity of research (ρ) is low. It is important to note that, even with endogenous taxes, the application of the correcting policy b^* enables the regulator to reach the first best level of human capital. However, under fiscal competition, a high level of human capital fosters fiscal competition and leads to underprovision of funds allocated to research. With fiscal competition, there is therefore a tradeoff between efficiencies in education and research and a potential underinvestment in both activities. The transnational entity should therefore tackle both the free-riding problem of university funding and the fiscal competition problem.

4 Concluding remarks

In this paper, we addressed the question of the impact of student and worker cross-country mobility on human capital production and research. We highlight an important implication of this mobility on the divergence between governments and universities' objectives. Indeed, universities care about prestige and the stock of human capital produced independently of its future location, whereas governments are not willing to finance the education of agents who will leave the country afterwards. Since governments are the first players of this game, the free-rider effect between governments dominates the competition effect between universities induced by student mobility. A positive transnational transfer made by the government of the country sending students abroad to the recipient country allows to correct this inefficiency. When government budgets and worker mobility are made endogenous with tax competition, the efficient level of teaching quality can be offered by universities, but may fail to prevent governments from engaging in fiscal competition with, as a result, a potential underinvestment in both teaching and research.

The model presented in this paper integrates many important features of this literature, such as student and worker mobility, quality competition by universities, university funding and fiscal competition by governments. From a technical viewpoint, this model is quite original in that it provides a non-cooperative solution to a game between two principals (governments) competing by designing incentives schemes for two competing agents (universities), who themselves rely on a third layer of players (the students). Still, the model does not allow for the possibility for universities to compete simultaneously in quality and prices, which are assumed to be zero. In the european context, this is an acceptable approximation, although integrating tuition fees into the analysis would be an interesting avenue for future research.

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