Subsidizing Heterogeneous Higher Education Systems

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Abstract

In many countries, there is an ongoing debate on the public funding of the higher education (HE) system. Our goal is to examine the theoretical justification for the establishment of HE institutions and analyse the self-selection of students under different policies of student subsidies. We study non-stationary equilibria of an OLG economy in a hierarchical education system. Given the capacity constraints of Universities, we explore the impact of adding new institutions, to be called Colleges, to the HE system, focusing on three issues. Given that Colleges are less productive and less selective than Universities, (a) Should the government establish Colleges? (b) Should the government divert funds from Universities to Colleges? Based on long-run economic growth considerations, we obtain positive answers to both questions. (c) Then, we compare several policies of student subsidies across the board. Our results suggest that much caution is needed in the implementation of student subsidies. Specifically, targeting subsidies to the highly-ranked students in each institution may distort their self-selection across institutions and downgrade the human capital accumulation in the economy. To offset this distortion in the demand for HE it may be useful to target subsidies to the low-ranked students in each institution. Our model also accounts for several stylized facts over time, (1) the increase in the number of institutions and students; (2) the decline in College admission standards; (3) the decline in public budget per student and the corresponding increase in out-of-pocket student payments.

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1. Introduction

In higher education (HE) systems, subsidies for highly-ranked students are quite popular and their growth-enhancing effect is considered unquestionable. The argument in favor of these subsidies, however, typically ignores some features of the evolution of HE systems in western countries during the 20th century. Particularly, the emergence of more and more heterogeneity in the HE system calls for an analysis of the effect of targeted subsidies on the self-selection of students across HE institutions. To fill this gap, we introduce a theoretical framework that considers the changing structure of the HE system over time. Using this framework, we uncover a potential distortion in the self-selection of students caused by targeted subsidies. Specifically, our results suggest that subsidies targeted to the highly-ranked students in each institution may induce students to downgrade their level of human capital. The solution we suggest in this paper is to mix these subsidies with subsidies targeted to low-ranked students (no need for extra budget). Based on our results, we argue that the design of student subsidy policies should take into account their effect on the self-selection of students. This additional consideration may enhance the accumulation of human capital in the economy.

Many European countries have experienced an expansion of their HE systems over time, in terms of both number of institutions and number of students. For example, Figure 1 documents the evolution of the HE system in Israel in the last 50 years. On the left axis, the number of institutions is marked in blue, and on the right axis, the number of students is marked in red. Figure 1 shows that since 1965 (7 Universities and about 15,000 students in Israel) the number of institutions has increased by about 10 times and the number of students has increased by about 17 times. Similarly, Cottini et. al (2017) document an increase in the number of Universities in the years 1859-2009 in France, Germany, UK, and Italy.

To analyze the expansion in HE systems over time, we consider a hierarchical education system. Young individuals attain compulsory (or basic) education and then optionally pursue HE to achieve supplementary skills. The demand for HE is endogenously determined by three heterogeneous factors of individual returns: the initial endowment of each student, the productivity (technology of human capital formation) of HE institutions and the cost of HE (the tuition fee determined by the

policy of student subsidies). Based on these considerations, individuals form the HE demand period by period. We characterize their choices and capture 'hidden' distortions in the self-selection of students across HE institutions under common student subsidy policies.

The two main messages of this article are the following. On the one hand, Colleges play a key role in the accumulation of human capital (or earning potential) in the economy. This argument challenges a common criticism on the allocation of public funds to HE systems, given the scarce resources and budgetary pressures[1]. On the other hand, in the presence of heterogeneous HE institutions caution is required in the allocation of student subsidies to subsets of students.

To study these issues, we use an Overlapping-Generations (OLG) open economy model, where intergenerational transfers (from altruistic parents to their child) take place. At the outset, the HE system relies mainly on Universities characterized by highly productive and selective HE system (say, due to better curriculum, faculty and experience), and publicly funded uniform student subsidies. Given the capacity constraints of the Universities, we consider the introduction of less selective HE institutions, to be called Colleges. Note that the terms 'Universities' and 'Colleges' are used for simplicity of presentation and basically capture the typical heterogeneity of HE institutions.

Using this framework, we address three issues that are often raised: (1) is it worthwhile to establish Colleges, or what is the justification for the observed expansion of the HE system through the introduction of more Colleges over time? (2) Should the government divert public funding from Universities to Colleges? (3) We further compare common policies of uniform and targeted student subsidies.

Our analysis suggests that whether the College students are subsidized by public funding or not, Colleges play a crucial role in the accumulation of human capital in the economy. Comparing dynamic competitive equilibrium paths period by period, we obtain the following results:

[1]The concern is that disadvantaged individuals contribute a portion of their wage income taxes to the HE budget but do not directly benefit from these investments (see Garrat and Marshall, 1994; Fernandez and Rogerson, 1995; Gradstein and Justman, 1995; Taber, C., 2001; Bevia and Iturbe-Ormaetxe, 2002). Moreover, it has been argued that improving the basic schooling, for example, may generate a higher social value than investing in HE (Johnson, 1984, Cunha et al., 2006).

(*a*) establishing Colleges improves the human capital accumulation in the economy. Moreover, over time the augmented level of human capital is both transferred to the child and yields more tax revenues (and thereby more funds for basic education and HE), boosting the demand for College along with a decline in College admission standards.

(b) Diverting funds from Universities to Colleges qualitatively affects the economic growth as in case (a), and further accounts for the worldwide shifts in HE systems towards smaller shares of public funding per student and higher out-of-pocket payments (see e.g., the UK, USA, the Netherlands and Israel). Therefore, based on long-run economic growth considerations it is recommended to establish Colleges and even divert some of the HE budgets from University students to College students.

(c) However, considering the form of funding, targeting subsidies to highly-ranked students (with high initial endowments) in each institution may have undesirable implications on their self-selection between Universities and Colleges, downgrading the accumulation of human capital in the economy (compared to uniform subsidies).

When subsidies are targeted to the highly-ranked students in each institution, naturally the University's low-ranked students are not eligible for a subsidy. However, if the same students opt out for a College instead, they may be eligible for a subsidy as the College's highly-ranked students ('big fish in a small pond'). As a result, these students face a trade-off between College subsidy and University productivity. Under certain circumstances, they may choose to study in a College although accepted to a University, gaining a lower level of human capital than otherwise gained in a University. To offset this distortion in the demand for HE it may be useful to target subsidies to the low-ranked students in each institution.

Our model is characterized by three-dimensions of heterogeneity. First, HE institutions are heterogeneous both in their productivity (or quality) and their selectivity (capacity of students). Second, individuals are heterogeneous in their 'initial endowments', determined by the random innate abilities and family backgrounds that shape the returns to education (standard to the theoretical literature on human capital formation, see e.g., Viaene and Zilcha, 2013).

Note that adding credit constraints in college enrolment decisions would not qualitatively change the main insights of this study. Moreover, much of the literature argues that family income and credit constraints play only a minor role in college

enrolment decisions once ability and family background are controlled for (Cunha et al., 2006, Bettinger et. al, 2014, see also Lochner and Monge-Naranjo (2011)).

Some features of our model have been analyzed before in different hierarchical education frameworks. Particularly, Driskill and Horowitz (2002) find that the optimal investment in hierarchical human capital exhibits non-monotonicity in human capital stocks. Su (2004) examines the efficiency and income inequality in a hierarchical education system and the effects of introducing subsidies to HE. Blankenau (2005) finds a critical level of expenditure above which HE should be subsidized because its impact on growth is positive. Arcalean and Schiopu (2010) study the interaction between public and private spending in a two-stage education system. They observe that increased enrolment in tertiary education does not always enhance the economic growth. Kaganovich and Su (2019) analyze the diverging selectivity of Colleges and its implications on the labor market. Eckwert and Zilcha (2020) consider within an information-based model the implications of Colleges to the human capital accumulation. Stenbacka and Tombak (2020) characterize the socially optimal level of public funding for Universities in a model with University-firm competition in basic research.

The remainder of the paper is organized as follows. Section 2 outlines the economic framework. Section 3 defines the equilibrium. Section 4 analyzes the emergence of Colleges, subsidizing Colleges, and various policies of student subsidies. Section 5 discusses robustness issues. Section 6 contains concluding remarks. Most of the proofs and figures are relegated to the Appendix.

2. The Economic Framework

In the following model we examine the implications of adding Colleges to the Higher Education system (which is originally composed of Universities only) and granting subsidies to their students on the accumulation of human capital (or earning potential). We apply a model similar to that used by Viaene and Zilcha (2013). We consider an OLG economy with a continuum of individuals in each generation. Each individual is characterized by a family name $\omega \in [0,1]$ where $\Omega = [0,1]$ denotes the set of all families in each generation and μ denotes the Lebesgue

measure on Ω. Individuals live for three periods: a youth period, a working period and a retirement period. During the youth period, individuals are engaged in education. Then, they live as adults for two periods: At the outset of their working period, they give birth to one offspring (the population growth is zero) and take economic decisions about their savings and the future of their child. In the retirement period, they simply consume their savings. While in each period three generations with the same family name co-exist (a child, a parent, and a grandparent), the analysis focuses on the behavior of parents, whose decisions matter for their child's level of human capital, and for the accumulation of human capital in the economy in the following periods.

Consider generation *t*, denoted by G_t, consisting of all children born at the outset of date *t*, and let $h_{t+1}(\omega)$ be their human capital level (specific to each child ω) at the beginning of their working period. We assume that $h_{t+1}(\omega)$ is achieved by a hierarchical (or two-stage) formation process of human capital like in Restuccia and Urrutia (2004)[2]. Specifically, a child ω in generation t, obtains general skills from fundamental, or basic education, X_t (assumed to be compulsory, common to all, and funded by public resources) and may additionally acquire specialized skills from HE. Each child is born with a random innate ability, $\tilde{\theta}_t(\omega)$, assumed to be independent and identically distributed across individuals in each generation and over time. The realization of ability, $\theta_t(\omega)$, is observed when the child is born. In addition to the innate abilities, the empirical literature has established that parental inputs and home environment together with school inputs are key factors affecting the level of human capital[3]. Accordingly, these inputs are included in our process of human capital formation.

The human capital of an individual $\omega \in G_t$ who does not enroll in HE, also

[2] Blankenau (2005), Hatsor (2015), and Gilpin and Kaganovich (2012) model education as a sequence of stages, where the human capital level achieved in lower stages acts as an input in the education technology at higher stages. See also Su (2004), Blankenau and Camera (2006), Kaganovich and Su (2019).

[3] See Keane and Wolpin (1997, 2010), Cameron and Heckman (2001), and Ge (2011). Investing in well-being and education early in life has high individual and social rates of returns and is a crucial preparation for subsequent stages of education (see a review of the evidence in several fields in Cunha et al. (2006)). Correspondingly, in a number of OECD countries (The Czech Republic, Germany, New Zealand and Poland) annual expenditures per student are higher on pre-primary education than on primary education.

called a **low-skilled worker** (denoted by *l*), is given by:

$$h_{t+1}^{l}(\omega) = \theta_t(\omega) h_t(\omega)^{\nu} X_t^{\xi} \quad (1)$$

where $h_t(\omega)$ stands for the parental human capital (specific to each parent ω). The elasticities ν and ξ represent the effectiveness of home and public inputs in educating the child, respectively. ν is affected by home education and family background while ξ is affected by schooling systems, teachers, size of classes, facilities etc.

Define $Z_{t+1}(\omega) = \theta_t(\omega) h_t(\omega)^{\nu}$, a product of both innate ability and parental human capital, as *the initial endowment* of the child ω, or the heterogeneous background conveyed prior to any formal education. In the sequel, the initial endowments play a crucial role in determining the sets of skilled and low-skilled workers in the economy.

Attending a University augments the basic skills (or the earning potential) by some factor $B > 1$ [4],

$$h_{t+1}^{s}(\omega) = B h_{t+1}^{l}(\omega) = B Z_{t+1}(\omega) X_t^{\xi} \quad (2)$$

He/she is then called a **skilled worker** (denoted by *s*).

However, HE is costly and (in most countries) requires the payment of a tuition fee, denoted by z_t^*, assumed to be exogenously given and accurately reflecting the cost of HE per student at date t. The government may subsidize part of the cost by taxing wage incomes. Denote by g_t the government (or public) uniform subsidy allocated to each student in the HE system at date *t*. Thus, $z_t(\omega) = z_t^* - g_t$ is the uniform out-of-pocket payment (or net tuition fee) of each parent at date *t* if their child attends HE, denominated in dollars of the working

[4] Assuming that *B* is time-independent simplifies our analysis without loss of generality.

period.[5]

The wage incomes of skilled workers and low-skilled workers are determined according to their human capital level, given in *Eq.* (1)-(2). The lifetime after-tax wage income earned by a low-skilled worker ω (that has no HE) and a skilled-worker (that acquires HE), respectively, in the working period is:

$$(1-\tau)h_{t+1}^{l}(\omega)w_{t+1} \tag{3}$$

and

$$(1-\tau)h_{t+1}^{s}(\omega)w_{t+1} \tag{4}$$

where w_{t+1} is the wage rate per unit of effective labor at date $t+1$, and τ is the education tax imposed on wage incomes, assumed to be exogenously given.

To further understand how individuals become skilled or low-skilled workers, we assume that the lifetime preferences of each parent $\omega \in G_{t-1}$ are represented by a Cobb-Douglas utility function,

$$U_t(\omega) = \left(c_t^a(\omega)\right)^{\alpha_1}\left(c_t^r(\omega)\right)^{\alpha_2}\left(y_{t+1}(\omega)\right)^{\alpha_3} \tag{5}$$

where consumption when 'active' (in the working period) and 'retired' are denoted by $c_t^a(\omega)$ and $c_t^r(\omega)$, respectively, and $y_{t+1}(\omega)$ is the offspring's lifetime income. That is, our framework assumes that parents are altruistic towards their child, deriving utility directly from the child's lifetime income[6].

The altruistic motives of parents are conveyed in three forms of intergenerational transfers to their child. The first two involve investment in education of the younger generation. First, parents pay taxes to finance the public education budget. Second, they pay the net tuition fee of HE. Lastly, parents transfer tangible

[5] Different combinations of tuition fees and government subsidies in our model can reproduce the relative shares of private investment and public investment in tertiary education observed in the data. For example, in 2006 the proportion of private funding of tertiary education ranged between 3.6% in Denmark and 83.9% in Chile (see OECD, 2009, Table B3.2b).

[6] This representation of parental altruism is more common and tractable than a dynastic model where the utility of all future generations enters the utility of the current generation.

assets, $(1+r_{t+1})b_t(\omega)$, like *inter-vivos* gifts and bequests, to their child (see Viaene and Zilcha, 2002; Zilcha, 2003). These financial transfers are the lifetime *non-wage* income of their offspring, that together with the *wage* income (*Eq.* 3 or 4) obtain the lifetime income of the child, $y_{t+1}(\omega)$[7].

Given the human capital levels of low-skilled and skilled workers, *Eq.* (1) and (2), it is straightforward to calculate variables at the economy level – the stock of human capital that serves as a primary factor in production and the government balance sheet. First, the stock of human capital, H_t, at date *t* is given by

$$H_t = \int h_t(\omega) d\mu(\omega) \tag{6}$$

The stock of human capital H_t is the sum of human capital of all individuals in generation G_{t-1} (all work at time *t*).

The second aggregate equation to be defined is the government balance sheet. The government (or public) budget at date *t* is balanced if the following identity holds[8]: $\tau w_t H_t = X_t + g_t \mu(A_t)$

The left-hand side is the government tax revenues (H_t is defined in *Eq.* (6)), and the right-hand side is the total expenditure on both stages of education, basic education, X_t, and HE. The expenditure on HE is g_t (the subsidy per student) multiplied by $\mu(A_t)$, the measure of HE students who are eligible for a subsidy at date *t*, where A_t denotes the subset of children in generation G_t who attend HE. To simplify the presentation, let γ be the fraction of government revenues allocated to basic education (the share of basic education).

Assumption 1 (A1): The fraction of the government budget devoted to basic education is exogenously given by $0 < \gamma \leq 1$, and the corresponding fraction of HE is $1 - \gamma$. Then:

[7] We assume that intergenerational transfers are unidirectional and therefore cannot take negative values along the equilibrium path.

[8] The importance of including both sides of the government balance sheet has been confirmed by empirical studies on growth effects of public education spending (see, e.g., Bassanini and Scarpenta, 2001; Blankenau *et al.*, 2007b).

(7) $$X_t = \gamma \tau w_t H_t$$

$$g_t \mu(A_t) = (1-\gamma)\tau w_t H_t$$

If $\gamma = 1$, the government revenues are fully allocated to basic education and not to HE, $g_t = 0$. We assume that γ is a fixed exogenous parameter and focus the analysis on the allocation of the HE budget, given its exogenous share, $1-\gamma$, in the government revenues.

Production is carried out by competitive firms that produce a single commodity which is both consumed and used as a production input. Physical capital K_t (assumed to fully depreciate) and the stock of human capital H_t (computed in *Eq.* (6)) are inputs of a neo-classical production function that exhibits constant returns to scale; it is strictly increasing and concave *(see more details about the aggregate production function in Viaene and Zilcha (2013))*.

We consider a small open economy that, as of date $t = 0$, is integrated into the rest of the world in two ways. First, the final good is freely traded which implies a single commodity price worldwide. Second, physical capital is assumed to be internationally mobile while labor is internationally immobile. With the small economy assumption, the return to capital $\{r_t\}$ must be equal to the foreign interest rate[9]. Since $\{r_t\}$ is fixed, the equation $F_K(K_t, H_t) = F_K\left(\frac{K_t}{H_t}, 1\right) = 1 + r_t$ determines the ratio $\frac{K_t}{H_t}$. The ratio $\frac{K_t}{H_t}$, in turn, determines the wage rate through $F_L\left(\frac{K_t}{H_t}, 1\right) = w_t$.

[10]. Under these common assumptions, any policy that leads to human capital accumulation is expected to temporarily increase the domestic marginal return to

[9] A more general assumption of partial capital mobility would not modify our results qualitatively. For example, suppose $\rho \neq 1$ denotes a constant proportional difference in the rate of return to physical capital between the domestic economy and the rest of the world. With capital market integration, the equality between rates of returns implies $r_t = \rho r_t^*$, where r_t^* is the foreign interest rate, and our results hold.

[10] Note that while the domestic wage rate is predetermined, it is not equal to the foreign wage rate as long as there are differences in production technologies. Only if production technologies are similar across countries, then the domestic wage rate equals the pre-determined foreign wage rate. Differences in production technologies across countries would cause a cross-country difference in wages and trigger international migration of labor.

physical capital and hence, bring about an inflow of foreign physical capital. The rise of both inputs of production must augment the domestic output as well. *Therefore, in our standard framework human capital growth directly translates to output growth. Then, it is important to note that while our propositions hereinafter address the effect of different policies on the human capital accumulation in the economy, in our framework the effect on output is qualitatively similar.*

Given the variables at the economy level (the stocks of physical capital and human capital, K_t, H_t , the share of basic education, γ, and the tax rate τ, parents in each period t make forward-looking decisions regarding financial transfers, $b_t(\omega)$, together with the level of savings, $s_t(\omega)$, and investment in the HE of their child, $z_t(\omega)$ considering the international prices of capital and labor $\{r_t, w_t\}$, so as to maximize their utility:

(8) $$MAX_{s_t,b_t,z_t}[U_t(\omega) = \left(c_t^a(\omega)\right)^{\alpha_1}\left(c_t^r(\omega)\right)^{\alpha_2}\left(y_{t+1}(\omega)\right)^{\alpha_3}]$$

subject to constraints:

(9) $$z_t(\omega) = 0 \quad \text{or} \quad z_t(\omega) = z_t^* - g_t \ , \ b_t(\omega) \geq 0$$

(10) $$c_t^a(\omega) = y_t(\omega) - s_t(\omega) - b_t(\omega) - z_t(\omega) \geq 0$$

(11) $$c_t^r(\omega) = (1 + r_{t+1})s_t(\omega) \geq 0$$

See a full characterization and solution of these equations, $\{(c_t^{\ a}(\omega), c_t^{\ r}(\omega), s_t(\omega), b_t(\omega), z_t(\omega)); w_t, r_t\}_{t=0}^{\infty}$ in the Appendix (*we rely on Viaene and Zilcha (2013)*).

Inserting the first order conditions (with respect to savings, $s_t(\omega)$, and financial transfers, $b_t(\omega)$) into the utility function (*Eq.* (8)) yields a reduced-form utility function:

(12) $$U_t(\omega) = \Phi\left(\frac{1}{1+r_{t+1}}\right)^{\alpha_1}\left[y_{t+1}(\omega)\right]^{\alpha_1+\alpha_2+\alpha_3}$$

where the parameter Φ is a constant independent of time and independent of ω Note that the reduced-form utility is proportional to the lifetime income of the offspring. *Consequently, in this framework maximizing the parental utility is the same as maximizing their offspring's future income. Thus, it is important to note that a utilitarian social planner is equally concerned with the aggregate parental utility and the next generation's aggregate income.*

The next step is to define the demand and supply for Universities, and thereby the set of skilled and low-skilled workers in the equilibrium. Then, we examine how the introduction of Colleges (subsidized or unsubsidized) affects the economy.

2.1. Demand and Supply of Universities

Using the reduced-form utility function, *Eq.* (12), parents decide whether to invest in the HE of their child by comparing his/her future lifetime incomes as a skilled worker or a low-skilled worker[11]. Their decision defines the demand for Universities, or the set of University applicants, U_t^D. *Define:*

$$\Lambda_t = \left(\frac{1}{1-\tau}\right)\left[\frac{1}{(B-1)\frac{w_{t+1}}{1+r_{t+1}}}\right]\left(\frac{z_t^* - g_t}{X_t^{\xi}}\right). \quad \textit{Then:}$$

(13) $$U_t^D = \{\omega \mid \quad Z_{t+1}(\omega) \geq \Lambda_t\}$$

That is, all individuals $\omega \in G_t$ with initial endowments above Λ_t generate the demand for Universities (see proof in the Appendix). The threshold Λ_t is positive because universities augment the earnings potential due to $B > 1$. The threshold Λ_t illustrates the role of relative returns and relative cost of Universities in the decision to apply a University. For example, the demand for Universities increases (Λ_t declines)

[11] Eicher (1996) and Hatsor (2012) also model a partition of the labor force between skilled and low-skilled workers but in contrast to our model, individuals make their own occupational choice based on their respective career paths as skilled or low-skilled workers.

if the returns to Universities rises, if Universities become less costly for the parents (the out-of-pocket payment $z_t^* - g_t$, declines), or if the basic education, X_t, improves.

After describing the demand for Universities, the next assumption addresses the supply of Universities. Typically, the demand for Universities (the set of applicants) is larger than the supply (the set of applicants who are actually accepted to Universities), because Universities have a binding capacity constraint. Denote by U_t the set of University students at date *t*. Note that for now, the set of HE students equals the set of University students, $A_t = U_t$, because Universities are the only HE institutions in our economy.

Assumption 2 (A2): *The set of HE students (accepted applicants) at date t, denoted by A_t, is given by:*

$$A_t = \{\omega \mid \ Z_{t+1}(\omega) \geq \lambda\}, \tag{14}$$

where $\lambda > \Lambda_t$ is an exogenous access restriction (or admission standard) imposed by Universities.

Figure 2 illustrates the selection of students to Universities. Because of the excess demand for Universities, the supply actually determines the set of students who attend Universities. Only applicants with sufficiently large initial endowment (above λ) are accepted to Universities and become skilled workers, while all other applicants (within $[\Lambda_t, \lambda]$) do not meet the University requirement and become low-skilled workers.

In many countries the excess demand for Universities has pushed towards the emergence of less selective HE institutions, to be called 'Colleges', that usually accept students with lower initial endowments. Recall that the terms 'Universities' and 'Colleges' are used for simplicity of presentation, and basically capture the typical heterogeneity of HE institutions.

2.2. Demand and Supply of Colleges

Typically, Colleges alleviate the access restrictions of Universities. For simplicity, we assume that the tuition fee is identical in Universities and Colleges,

and that Colleges accept all applicants (the College admission standard is determined by the demand for Colleges). As a result, individuals with initial endowments $[\Lambda_t, \lambda]$, who are not accepted to Universities, can now attend Colleges if they wish.

Nevertheless, the demand for Colleges is lower than the demand for Universities because of two reasons: College quality and College cost. First, College quality (or productivity) is lower than University quality. That is, while Universities augment each individual's basic skills by some quality factor $B > 1$, we assume that Colleges have a lower productivity factor because of inferior facilities, research, experience or curriculum, $B > B_C > 1$ [12]. Accordingly, if agent ω attends a College, his/her human capital level is:

$$h_{t+1}^{c}(\omega) = B_c h_{t+1}^{l}(\omega) = B_c Z_{t+1}(\omega) X_t^{\xi} \tag{15}$$

Besides their lower productivity, the second reason for the lower demand for Colleges is that, in some cases, the government may allocate smaller funds to Colleges, reflected in their student subsidies. Accordingly, we assume for now that the government does not participate in the cost of Colleges, and therefore College students pay the whole tuition fee. We discard this assumption later.

Formally, denote by g_{ct} the government (or public) allocation to each College student. Thus, $z_{ct}(\omega) = z_t^* - g_{ct}$ is the out-of-pocket payment of College students where $g_{ct} = 0$ for now. Because of their seemingly lower quality and larger cost, Colleges are 'less attractive' than Universities for now in the sense that the demand for Colleges is lower than the demand for Universities.

Next, let us define the demand for Colleges. Using the reduced-form utility, *Eq.* (12), parents whose child is not accepted to a University decide whether to apply to Colleges by comparing the future lifetime incomes of their child as a College-educated worker or a low-skilled worker. Because all applicants are accepted to Colleges, the demand for Colleges determines the set of College students at date *t*, C_t. *Define the College admission standard (or the threshold between College and University students)*

[12] See Hotchkiss and Shiferaw (2011) and the references therein for measurement and estimation methodologies of the education wage gap between College workers and low-skilled workers.

as,

$$\Lambda_{ct}=\left(\frac{1}{1-\tau}\right)\left[\frac{1}{(B_c-1)\frac{w_{t+1}}{1+r_{t+1}}}\right]\left(\frac{z_t^*-g_{ct}}{X_t^{\xi}}\right). \quad \textit{Then:}$$

$$C_t=\{\omega \mid \lambda \geq Z_{t+1}(\omega)\geq \Lambda_{ct}\} \tag{16}$$

That is, all individuals $\omega \in G_t$ with initial endowments $[\Lambda_{ct},\lambda]$ attend Colleges, where λ, the exogenous access restriction imposed by Universities, satisfies $\lambda > \Lambda_{ct}$ (see proof in the Appendix). The threshold Λ_{ct} is positive because Colleges augment the earnings potential, $B_c > 1$), and is determined by the relative returns and the relative cost of College education. It sheds some light into the large cross-country variations in the skill composition of the work force[13]. The demand for Colleges increases (Λ_{ct} declines) if the returns to Colleges rises, if Colleges become less costly (the out-of-pocket payment, $z_t^* - g_{ct}$, declines), or if the basic education, X_t, improves.

Figure 3 illustrates the self-selection of students to Universities and Colleges. While all individuals with sufficiently low endowments (below Λ_{ct}) become low-skilled workers, all other individuals (above Λ_{ct}) become skilled workers: The set $[\Lambda_{ct},\lambda]$ attends Colleges and students with initial endowments above λ attend Universities (these groups are also called College students and University students, respectively). The self-selection of individuals to the three levels of education (Universities, Colleges, and basic education) completes the model. Next, we use the model to examine the evolution of the HE system – emergence of Colleges, subsidizing Colleges and policies of student subsidies.

3. Competitive Equilibrium

In our open economy, given the international interest rates r_t at date t (t =0, 1, 2...), the stock of human capital, H_t, is given by $H_t = \int h_t(\omega) d\mu(\omega)$ (Eq. 6), the stock

[13] For example, in the year 2007, the share of skilled workers (approximated by the share of age group 25-64 with upper secondary education), was 27, 29, and 33 percent in Portugal, Turkey and Mexico and 80, 88, and 89 percent in Israel, Estonia, and Russian Federation, respectively (see OECD, 2009, Table A1.2A, column 1).

of physical capital, K_t, is determined by $F_K(K_t, H_t) = F_K\left(\frac{K_t}{H_t}, 1\right) = 1 + r_t$, and the wage rate, w_t, is determined by $F_L\left(\frac{K_t}{H_t}, 1\right) = w_t$. Then, given the stock of human capital, H_t, the tax rate τ, and the (exogenous) fraction of the government budget devoted to basic education γ, the basic education budget is given by $X_t = \gamma\tau w_t H_t$, and the HE budget is given by $(1-\gamma)\tau w_t H_t$ (Eq. 7).

Given the variables at the economy level (K_t, H_t, r_t, w_t, γ, τ) and the exogenous access restriction imposed by Universities, λ, the levels of parental consumption, savings, financial transfers, and investment in the HE of the child, $\{(c_t^a(\omega), c_t^r(\omega), s_t(\omega), b_t(\omega), z_t(\omega))\}_{t=0}^{\infty}$, maximize parental utility (see Eq. (8)-(11)).

In section 2.1, we described the case where Universities are the only type of HE institutions. In equilibrium, the HE budget constraint holds, $g_t \mu(A_t) = (1-\gamma)\tau w_t H_t$, where each student receives a uniform subsidy level of g_t. The set of HE students is determined by the binding capacity constraint of Universities, λ, where $A_t = \{\omega \mid Z_{t+1}(\omega) \geq \lambda\}$ (Eq. (14)).

In section 2.2, we added Colleges, and correspondingly the set of HE students, A_t, is composed of the set of University students, U_t (defined in Eq. (14)), and the set of College students, C_t, determined by the demand for Colleges. That is, using the reduced-form utility, Eq. (12), parents whose child is not accepted to a University apply to Colleges if the future lifetime incomes of their child are larger as a College-educated worker than as a low-skilled worker. This condition yields the College admission standard in Eq. (16), $\Lambda_{ct} = \left(\frac{1}{1-\tau}\right)\left[\frac{1}{(B_c - 1)\frac{w_{t+1}}{1+r_{t+1}}}\right]\left(\frac{z_t^* - g_{ct}}{X_t^{\xi}}\right)$, and the set of College students, $C_t = \{\omega \mid \lambda \geq Z_{t+1}(\omega) \geq \Lambda_{ct}\}$. Accordingly, when Universities and Colleges co-exist, the HE budget constraint is given by $g_t \mu(U_t) + g_{ct} \mu(C_t) = (1-\gamma)\tau w_t H_t$.

4. Results

We investigate the consequences of the heterogeneity of HE institutions considering both the vast expansion of the HE system and various governmental policies towards student subsidies.

4.1. Emergence of Colleges

Colleges alleviate the excess demand for the regime where only Universities exist by offering an alternative to this HE system to include Colleges, and hence expanding the set of skilled workers, A_t.

Not only individuals with initial endowments above λ attend Universities, but also individuals within $[\Lambda_{ct}, \lambda]$ attend Colleges. There are **two** immediate questions: (a) is it worthwhile to establish Colleges; or specifically, does the resulting expansion of the set of skilled workers lead to a higher stock of human capital in the economy? (b) is it justified to divert public funding to Colleges? The next proposition answers the first question.

Proposition 1 compares a regime with only Universities to a regime where both Universities and Colleges co-exist.

Proposition 1: *The emergence of Colleges at date t augments the human capital stock in the economy and reduces College admission standards in* ***all*** *subsequent periods* $t+k$, $k \geq 1$.

After Colleges are established, some individuals study in College instead of being low-skilled workers. In the subsequent periods, the low-skilled workers who have joined College increase the stock of human capital. Furthermore, their augmented human capital increases the initial endowments of their child, $Z_{t+1}(\omega)$, inducing more children to apply to HE. As a result, the set of skilled workers, A_t, increases over time. Moreover, the augmented human capital levels further increase incomes, and thereby tax revenues. The additional tax revenues increase the public funding for education, causing a decline in the College admission standard, Λ_{ct}, over time along with the increasing demand for Colleges.

A fair question would be – why establish Colleges rather than more Universities

that could raise aggregate human capital even further? Our answer is that if possible then we would prefer to establish the more productive HE institutions, Universities. However, a critical assumption of our framework is that Universities are selective (or capacity constrained). Universities accept only applicants with high potentials (ability in combination with family background). This assumption that HE institutions are heterogeneous not only in their level of productivity but also in their selectivity criterion is a stylized fact in many countries. HE institutions around the world impose access restrictions that typically generate excess demand of students and a shift of students to less selective institutions.

Given the strict selectivity criterion of Universities (which are favorable in their contribution to the aggregate human capital, but cannot or would not accept students with lower potentials), we consider the introduction of less selective HE institutions, Colleges, that accept anybody willing to pay the tuition fee. Thus, the answer to the above question is that in our framework while the first-best option with respect to the accumulation of human capital is Universities, the feasible option for Individuals with lower potentials is Colleges.

Another point relates to cost of establishing and maintaining Universities, which, in most countries, are also *research institutes*, hence faculty members in Universities are required to engage also in research. This fact has two implications: (a) it takes longer to establish a University (recruiting suitable highly qualified faculty members), and (b) the cost to establish and maintain a University is higher than that of establishing a College.

Thus, in proposition 1, we prove that except for the initial period, establishing Colleges (although second-best option with respect to the accumulation of human capital) yields higher stocks of human capital in all subsequent periods and a decline of College admission standards over time, leading to our second question about subsidizing Colleges.

4.2. Subsidizing Colleges

Next, we examine the implications of diverting public funding from Universities to Colleges (given the exogenous tax rate τ and the exogenous share of HE in the public budget, $1-\gamma$). In this section, we assume that subsidies are **uniform**. **That is, the HE budget is equally divided between all eligible students**. We discard

this assumption in the following section. In proposition 2, we assume **co-existence of Universities and Colleges** and compare two cases: a regime where only University students are eligible for a subsidy vs. the case of equally subsidized Universities and Colleges. In the first case, uniform subsidies are allocated to University students, $g_t > 0$, whereas in the second case all students enjoy uniform subsidies, $g_{ct} = g_t$. Comparing these two regimes, we assess how subsidizing Colleges affects the economy. Specifically, we explore whether College subsidy reinforces the positive effect of the emergence of Colleges on the human capital accumulation described in Proposition 1.

Proposition 2: *Assume co-existence of Universities and Colleges. Subsidizing College students as of date t augments the human capital accumulation in the economy and reduces the College admission standards in* ***all*** *subsequent periods* $t+k,\ k \geq 1$.

Dividing the public budget between more students (adding the College students to the pool of students equally eligible for a subsidy) reduces the subsidy per student in the initial period, $g_t = g_{ct} = \frac{(1-\gamma)\tau w_t H_t}{\mu(A_t)}$. Accordingly, the out-of-pocket per-student payment, $z_t(\omega) = z_t - g_t$ rises, accounting for the recent shifts in many Western countries from public HE funding (through various forms of subsidies) to regimes with larger out-of-pocket payments. It is important to note, though, that because uniform subsidies are equally divided to University and College students (i.e., all students are eligible for the *same* level of subsidy), there are no general equilibrium effects on the selection of students between Universities and Colleges. That is, with identical out-of-pocket payments to all students, Universities – the more productive institutions, remain the first choice of applicants (who consider applying to Colleges only if not accepted to Universities). Indeed, subsidizing Colleges induces more applications to Colleges, but not at the expense of University students.

Therefore, the effect of College subsidy is qualitatively similar to that of emergence of Colleges discussed in the previous section. The College admission standard, Λ_{ct}, declines, attracting more students to the HE system at the expense of the set of low-skilled workers. In the following periods their augmented human capital level as College-educated workers positively affects the accumulation of human capital in

the economy through several channels. First, their incomes rise, increasing the tax revenues allocated to basic education and HE, and thereby reducing the College admission standard, Λ_{ct}, over time. Second, their augmented human capital level is transferred to their child's initial endowment, encouraging the self-selection to HE. As a result, the set of College students increases over time (at the expense of the set of low-skilled workers).

Our results suggest that under capacity constraints of Universities, establishing and subsidizing less productive and less selective institutions enhances the economic growth[14]. This is true under the assumption that student subsidies are uniform. In the next section, we examine other policies of student subsidies, and show that our qualitative results remain as long as Universities 'dominate' Colleges as the first choice of students.

4.3. Policies of student subsidies

In this section we examine common policies of student subsidies (see Blankenau et al., 2007a). Specifically, we compare uniform subsidies to subsidies targeted to highly- (low-) ranked students. The policies are equally implemented in all HE institutions, Universities and Colleges alike.

To fix ideas, define a subsidy targeted to highly-ranked students as a subsidy to some exogenously given measure of top students within each institution at date t, S_t^H. That is, students are eligible for the subsidy if they are ranked among the top S_t^H percent students within their institution. For example, if $S_t^H = 10$, then the top 10 percent University students and the top 10 percent College students are eligible for the same level of subsidy (that balances the HE budget). Note that $S_t^H = 100$ denotes the case of uniform subsidies for all HE students – 100% of the students in each institution are eligible for a subsidy (the case discussed in the previous section). Similarly, a subsidy targeted to low-ranked students is defined by S_t^L, the percentage of low-ranked students in each institution eligible for a subsidy.

[14] Hatsor (2014) suggests that allocating more funds to a less productive education system may be the optimal choice of the majority of voters and may explain the observed 'budget puzzle', or why educational expenditures seem to be unrelated to educational achievements. Fan et. al (2020) analyze the optimal allocation of public expenditures among competing functions.

Subsidies for highly-ranked students are quite popular and typically considered growth-enhancing. The foregoing study is the first, to the best of our knowledge, to challenge this premise within the education system by addressing the impact on the self-selection of students across HE institutions. We argue that highly-ranked student subsidies may motivate students to downgrade their level of human capital. The reason is that while the student subsidy policy is equally implemented in all HE institutions, the rank of each student relative to the other students in a given institution differs across institutions. Naturally, the students ranked as the top 10 percent in a College are not the same students as the top 10 percent in a University. Therefore, the same student may be eligible for a subsidy in one institution but not in the other.

Specifically, given that in our framework the distribution of students' initial endowments is more competitive in the Universities than in the Colleges, any student improves her relative rank within an institution by enrolling in a College rather than a University (becoming 'a big fish in a small pond'). Suppose, for example, that a subsidy is provided to the top 10 percent students in each institution. Then, the top potential College student is eligible for this subsidy if she attends a College but not if she chooses a University. Therefore, subsidies targeted to highly-ranked students (equally implemented in all HE institutions) may potentially provide incentives for students to enroll in Colleges rather than Universities, as we discuss in the sequel. Note that this argument can be easily extended to a more general heterogeneous HE framework.

Our benchmark case (also referred to as 'uniform subsidies') is the one discussed in the previous section, where all students enjoy uniform subsidies, $g_{ct} = g_t$, and consequently their out-of-pocket payments are identical in Universities and Colleges. In this case, Universities are always 'more popular' than Colleges because they are more productive (augmenting the basic skills of their graduates by a larger productivity factor, $B > B_C > 1$). With a similar payment and higher returns to their graduates, Universities are the first choice of students, or the dominant institutions in the market of HE. Students may apply to Colleges only if they fail to pass the University access restriction, λ.

This raises two questions. Given that Universities are more productive than Colleges, and subsidies in Colleges and Universities are provided according to the same policy: (a) is it possible that under certain funding policies Colleges become the first

choice of certain students; namely, they attend Colleges although they are accepted to Universities? (b) What are the economic consequences of Colleges becoming the first choice for some students, breaking the University dominance in the market?

To answer these questions, we compare the benchmark case of uniform subsidies ($S_t^H = 100$) to subsidies targeted to subsets of students, focusing on their self-selection across HE institutions. Figure 4 illustrates the self-selection of students when subsidies are targeted to highly-ranked students in each institution ($S_t^H < 100$). In contrast to the case of uniform subsidies (qualitatively described by Figure 3), an additional set of students C'_t may pursue College education as their first choice although accepted to Universities. *A necessary condition for C'_t to be nonempty is that students in the set C'_t are eligible for a* subsidy *($g_{ct} = g_t$) if they attend a College but not if they attend a University. Define:*

$$\Lambda_{c't} = \left(\frac{1}{1-\tau}\right)\left[\frac{1}{(B-B_c)\frac{w_{t+1}}{1+r_{t+1}}}\right]\left(\frac{g_{ct}}{X_t^{\xi}}\right). \quad \textit{Then:}$$

$$C'_t = \{\omega \mid \lambda < Z_{t+1}(\omega) \le \Lambda_{c't}\} \tag{17}$$

That is, all individuals $\omega \in G_t$ with initial endowments in $[\lambda, \Lambda_{c't}]$ attend Colleges as their first choice (although accepted to Universities). Moreover, this set expands ($\Lambda_{c't}$ rises) as both the College subsidy, g_{ct} , and the College productivity, B_c , rise, and as the investment in basic education, X_t , declines).

A relatively low level of basic education alleviates the differences in productivity between Universities and Colleges and thus encourages students to opt out from Universities to Colleges.

In the benchmark case, $S_t^H = 100$, all students are eligible for a subsidy. In this case, because the productivity of Universities is larger than the productivity of Colleges, and the subsidy is the same, all students prefer universities as their first choice; or formally $\Lambda_{c't} = \lambda$ and the set C'_t is empty. Now, suppose that the policy of uniform subsidies is replaced by a policy of subsidies targeted to highly-ranked students. That is, the percentage of top students who are eligible for a subsidy in each

institution declines to some $S_t^H < 100$, which in turn reduces the measure of HE students who receive a subsidy, $\mu\left(U_t, C_t, S_t^H\right)$. Consequently, to balance the HE budget (given by the exogenous levels of tax rate τ and the share of HE budget, $1-\gamma$), the student subsidy, $g_{ct} = g_t = \frac{(1-\gamma)\tau w_t H_t}{\mu\left(U_t, C_t, S_t^H\right)}$, must increase in the equilibrium. The larger College subsidy, induces a shift of students from Universities to Colleges, thereby $\Lambda_{c't}$ rises.

When subsidies are targeted to the highly-ranked students in each institution, by definition students with the lowest initial endowments in Universities are not eligible for a University subsidy, but are considered the most favorable College applicants and as such are being offered College subsidies ('Big fish in a small pond'). Their eligibility for a College subsidy but not for a University subsidy generates a trade-off between Universities (more productive) and Colleges (less costly), and they prefer Colleges if both the College subsidy and productivity are relatively high. Therefore, these targeted subsidies may push University applicants to Colleges (as their first choice), downgrading their level of human capital.

Additionally, a shift from uniform subsidies to subsidies for highly-ranked students implies that College applicants with low initial endowments are not offered a subsidy, providing them negative incentives to pursue HE altogether (compared to the case of uniform subsidies the threshold Λ_{ct} rises). These potential shifts of students to a lower quality level of education (from Universities to Colleges and from Colleges to basic education), reduce the human capital accumulation in the economy in all subsequent periods.

Proposition 3: *In the presence of uniform student subsidies in Universities and Colleges, a shift towards subsidies targeted to the highly-ranked students in each institution may lower the human capital stock in all subsequent periods.*

However, the shift of students to a lower quality level of education can be alleviated by subsidies targeted to **low-ranked** students in each institution. These

subsidies provide counter-incentives for students to prefer Universities rather than Colleges. Moreover, subsidies targeted to low-ranked students prevent College students from dropping out of College, shifting them to a higher level of human capital.

> **Proposition 4:** *In the presence of uniform subsidies in Universities and Colleges, a shift to subsidies targeted to the low-ranked students in each institution may raise the stock of human capital in all subsequent periods.*

The proofs of propositions 3 and 4 are straightforward and are available upon request. To illustrate the effect of targeted subsidies, let us compare two funding schemes. Suppose that initially the top $S_t^H = \delta$ percent students in each institution are eligible for a subsidy. Consequently, some of them are tempted to attend a College although accepted to a University, which imposes a distortion in their self-selection, as previously discussed. Then, the government considers a 'mixed' funding scheme. In the mixed funding scheme, the *same* HE budget finances two types of subsidies – subsidies for highly-ranked students and subsidies for low-ranked students. Specifically, $S_t^H = S_t^L = \delta$, the top δ percent and the lowest δ percent students in each institution are eligible for a subsidy. Note that in order to balance the HE budget, the student subsidy, $g_{ct} = g_t = \dfrac{(1-\gamma)\tau w_t H_t}{\mu\left(U_t, C_t, S_t^H, S_t^L\right)}$, must be smaller in the mixed funding scheme. In other words, compared to the initial funding scheme, subsidies for highly-ranked students are diverted to low-ranked students.

The mixed funding scheme alleviates the distortion in the self-selection of students compared to the initial funding scheme because of several reasons. First, the top δ percent of College students are eligible for a smaller subsidy. Second, some of these highly-ranked College students are also eligible for a subsidy in a University (as the low-ranked University students). Obviously, with the same out-of-pocket payment these students prefer Universities, the more productive institutions, as their first choice and thereby upgrade their level of human capital relative to the initial funding scheme. Third, the subsidy to a δ percent of low-ranked students prevents students from dropping out of College. Therefore, adding subsidies to low-ranked students shifts students to a higher quality level of education, alleviates the distortion in their self-selection and augments the human capital accumulation in the economy.

Note that the distortion is eliminated completely if Universities are larger in size than Colleges. In this case, more University students are eligible for each subsidy in absolute values. As a result, all students who are eligible for a College subsidy are also eligible for a University subsidy, and thereby Universities remain their first choice.

This example illustrates the general conclusion from propositions 3 and 4: targeting subsidies to the highly-ranked students in each institution is counter-productive. First, it may cause a distortion in the self-selection of students across HE institutions. Students may prefer College subsidy over University productivity (although accepted to Universities). Replacing these subsidies with subsidies targeted to low-ranked students generates an offsetting effect that alleviates this distortion and restores the incentives of students to apply to Universities.

Second, students with high potentials do not need additional incentives in order to opt for HE. However, since the subsidies are financed through general taxation, they destroy the incentives of some individuals with low potentials to apply to HE. Therefore, diverting the subsidies to low-ranked students improves the accumulation of human capital in the economy by upgrading their level of education.

We assumed throughout the article that the policy of subsidies cannot favor Colleges. Note that if this is not the case, and for some reason all subsidization can be targeted to Colleges, then an additional conclusion is straightforward,

> **Proposition 5:** *In the presence of uniform subsidies in Universities and Colleges, a shift to subsidies targeted to the low-ranked students in Colleges raises the stock of human capital in all subsequent periods.*

Targeting all subsidies to low-ranked students in Colleges maximizes the stock of human capital in our framework, because these subsidies upgrade the level of human capital of students who would otherwise remain low-skilled. While this subsidization policy prevents dropping out of College, the HE decisions of other students are unharmed. This is because students who are accepted to Universities are not eligible for a subsidy neither in a College nor in a University, and consequently they prefer to attend Universities, the more productive institutions.

5. Robustness

The key assumption in this article is that the more productive (and thus more popular) HE institutions are also more selective. That is, their high admission standard generates excess demand which is not resolved by the price mechanism (tuition fee) in the equilibrium. This feature is quite realistic in many countries. HE institutions around the world impose access restrictions that typically generate excess demand of students.

An important question that emerges here is why do they keep the price low, instead of increasing the tuition fee as long as there is excess demand? One reason could be reputation and exclusivity concerns. Instead of shifting their tuition fee upwards, they may prefer to maintain the excess demand in order to signal their quality and ensure that they attract the top-ability students (instead of the most advantaged students). Moreover, in Nordic countries, Israel, the US, and other countries HE institutions are publicly-funded or private-not-for-profit organizations. Specifically, tuition fees may be supervised or even fully-determined by public officials whose goal is to provide equal opportunities in HE.

Accordingly, in our framework the tuition fee accurately reflects the cost of HE per student and cannot rise, whether because of government restrictions or simply because HE institutions are public or not-for-profit organizations[15]. Although our assumption about the tuition fee seems to properly describe the HE system in many countries, we shall discuss its robustness by providing both some empirical evidence and a theoretical discussion[16].

If excess demand for more productive HE institutions leads to a relative rise in their prices, we would expect to observe a positive relation in the data between the quality of HE institutions and their net price. To investigate the link between quality and price in the HE system, we use the 'Forbes America's top Colleges 2019', a list of the top 650 undergraduate institutions in the USA. The list contains name, state, net price, type (public or private not-for-profit), and two common measures for quality of

[15] This assumption is justified also under perfect competition in the long run. Perfect competition in the HE system leads to zero profit in the long run, so the price converges to the cost of HE.
[16] We thank our anonymous referee for raising the robustness issues.

HE institutions – their ranking (1 is the highest and 650 is the lowest ranking) and the early career salary (in thousands of dollars).

In Figures 5a-5b we plot the net price (in thousands of dollars) VS the measures of quality, focusing on the top **100** US institutions (ranked 1-100). In Figure 5a, we present the net price as a function of the institution's ranking. According to Figure 5a, the more exclusive institutions (with the *lowest* ranking) are also the more competitive in prices (see for example the prices of Harvard, Stanford and Yale). The net price in the top 100 institutions starts from about 20,000$ and an increase of one point in the ranking (i.e., a deterioration in the measure of quality) adds about 50$ to the net price of the institution. The same pattern appears in Figure 5b, where we replace the ranking with the other measure for quality – early career salary. Particularly, an increase of a dollar in the early career salary is related to a reduction of 23 cents in the institution's net price. Apparently, graduates of the best HE institutions enjoy not only the ranking of the institution and high early career salary, but also a *low* net price as well[17].

In Figure 5c, we focus on the **public** HE institutions in our sample (200 from a total of 650 institutions). Figure 5c shows strikingly no significant correlation between the early career salary in public institutions and their net price. Comparing the means of the net price and early career salary in public and private institutions in our sample confirms this observation. There is no significant difference between the average early career salary of public and private institutions' graduates (roughly 53,000$) in our sample. However, the average net price of public institutions, about 15,000$, is lower than private institutions' price by about 40% (the y-axis in Figure 5c ranges from 0-30 instead of 0-50 in all other figures). To summarize, Figures 5a-5c support our assumption, at least in the US top 100 HE institutions and in the public institutions, that the price mechanism may not equally apply in the HE market. Otherwise, excess demand would simply drive up the net price of the more productive institutions.

[17] Importantly, Pvalues of 10% and 6.6%, respectively, seem to us quite plausible given the small sample of top 100 institutions. However, even if we doubt the significance of the positive price-quality correlation implied by the regressions in Figures 5a-5b, these Pvalues imply that a negative correlation is unquestionably insignificant in this sample.

Having said that, we repeated the exercise for the whole sample of **650** top HE institutions. Figures 5d-5e show that for the whole sample, the results are reversed. That is, higher quality is positively related to the net price. Specifically, according to Figure 5d, an increase of one point in the ranking (i.e., a deterioration in the measure of quality) reduces about 10$ from the net price of the institution. Additionally, Figure 5e shows that an increase of a dollar in the early career salary of the institution's graduate is related to an increase of 21 cents in its net price.

To summarize so far, the price mechanism seems to work properly in the whole sample, but not in the US top 100 institutions or in public institutions. We rationalize these results by different incentives (or different government supervision on the price) of public VS private institutions and also different reputation and exclusivity concerns at the top 100 institutions. That is, instead of shifting their tuition fee upwards, they prefer to maintain the excess demand in order to signal their quality and ensure that they attract the top-ability students without financial constraints.

This evidence raises a concern for the robustness of our results to the case of private HE institutions[18]. To address this concern, we made the following change to our model. *Suppose that Universities are private in the sense that their tuition fee is not supervised by the government. That is, competitive forces apply in the HE market, so the price mechanism offsets any excess demand. Specifically, the excess demand for Universities drives up the tuition fee above the cost of HE, such that* ρz_t^*, $\rho > 1$ *, until there is no excess demand.*

The capacity constraint of Universities, λ, is still binding (inflexible supply of Universities). However, studying in Universities becomes more expensive until the price clears the market and only students with initial endowments above λ choose to apply Universities (no excess demand). Then, we keep our assumption that Colleges accept all applicants and their tuition fee remains z_t^*. Note that in this model of private Universities there is room for Colleges not because of the excess demand for Universities, but because of the price gap between the two type of institutions. That is, students may prefer a College not because they are not accepted to a University, but because a University is too expensive.

Analyzing this model of private Universities, we obtain that this framework is

[18] We thank our anonymous referee for bringing this to our attention.

robust to our results about the policies of student subsidies (section 4.3, Propositions 3-5). Specifically, targeting subsidies to highly-ranked students within each institution motivates certain students to downgrade their level of education. Some students apply to a College instead of a University, because they are eligible for a student subsidy only within Colleges, and others drop-out of College, reducing the accumulation of human capital in the economy. This distortion in the self-selection of students is alleviated by targeting subsidies to the low-ranked students in each institution (or only in Colleges). This subsidy policy restores their incentives to upgrade their education and in turn enhances the accumulation of human capital in the economy.

While a model of private Universities is robust to policies of student subsidies, its robustness to our results on the emergence of Colleges, uniformly subsidized or not (Propositions 1-2), requires more caution. These Propositions hold under an additional assumption: *Universities' capacity is sufficiently large (the capacity constraint, λ, is sufficiently low)*. In this case, Universities are ready to accept more students, and therefore in the equilibrium they are not too expensive. That is, the price gap that supports no excess demand for Universities, ρ, is small. Consequently, the larger productivity of Universities combined with a relatively small price gap ensures that all students who are accepted to Universities also prefer Universities (whereas a large price gap may attract them to Colleges and distort their self-selection). As a result, assuming that Universities' capacity is sufficiently large ensures that the emergence of Colleges (uniformly subsidized or not) augments the stock of human capital in the economy.

To summarize the empirical evidence and theoretical discussion, our framework suits public HE institutions as well as the top 100 HE institutions in the US and other countries. Pushing our model towards the case of private institutions, most of our results (Propositions 3-5) continue to hold, whereas Propositions 1-2 require an additional assumption, that the capacity of Universities (or their productivity) is sufficiently large.

6. Conclusion

To summarize our main contribution, we examine the emergence of heterogeneous HE institutions considering both the vast expansion of the HE system and various policies of student subsidies. This study is the first, to the best of our knowledge, to challenge the premise that subsidies for highly-ranked students always enhance human capital stocks, hence growth, by analyzing their effect on the self-selection of students across HE institutions. This effect should be taken into consideration by policy-makers, though it may not necessarily offset the well-known positive effects of these subsidies.

Comparing the dynamic equilibrium paths period by period, our findings demonstrate that the emergence of Colleges, whether subsidized or not, enhances the human capital accumulation in the economy. Moreover, it has positive implications to the welfare of future generations and, under certain conditions, facilitates the access of the disadvantaged individuals to HE.

Our results further suggest that much caution is needed in planning and implementing the student subsidies regime in order to avoid distortion in the self-selection of students across this heterogeneous HE structure. When subsidies are targeted to highly-ranked students within each institution, certain students are eligible for a student subsidy only within the College institutions (as 'the big fish in a small pond'). This financial incentive may generate a shift of students from Universities to Colleges and further from Colleges to no HE altogether, reducing the accumulation of human capital in the economy. However, targeting subsidies to the low-ranked students in each institution generates a counter effect that alleviates the distortion in the self-selection of students and restores students' incentives to apply to HE institutions. Their HE attendance upgrades their own human capital and in turn enhances the accumulation of human capital in the economy.

Our key assumption that HE institutions are heterogeneous in their levels of productivity and in their selectivity criterion is quite realistic in many countries. HE institutions around the world impose access restrictions that typically generate excess demand of students and a shift of students to less selective institutions. We assume that the excess demand for the exclusive institutions is not resolved by the price mechanism.

We examine the robustness of this assumption both empirically and

theoretically. Specifically, we observe a positive price-quality correlation in a sample of the US top 650 HE institutions, but not among the top 100 US institutions or among public institutions. This evidence indicates that the market forces may work better in private institutions, pushing the price upwards in case of excess demand. Based on this evidence, we revisit our model in the case of private institutions and a flexible price mechanism. While we reinforce our insights on the policies of student subsidies (Propositions 3-5 on targeting highly-ranked or low-ranked students), our results about the emergence of Colleges, uniformly subsidized or not (Propositions 1-2), hold under an additional assumption – that the capacity of Universities is sufficiently large.

Future study may endogenize the reputation of HE institutions and their ways to attract students besides student subsidies. These may include better 'services', quality and availability of staff and teachers, a friendlier approach, college campus visits, letter campaigns, flexible schedules, convenient locations, labor-market oriented programs and others (see Kaganovich and Su, 2019; Eisenkopf and Wohlschlegel, 2012; Swanson et. al, 2019; Barham, 2019). Future study may also consider peer effects generated by the self-selection of students and how student subsidies affect the individual incentives to invest effort in their basic education. We have also ignored the important issue of the probability to drop out from HE (and remain low-skilled) due to the unsuitable choice of a HE institution.

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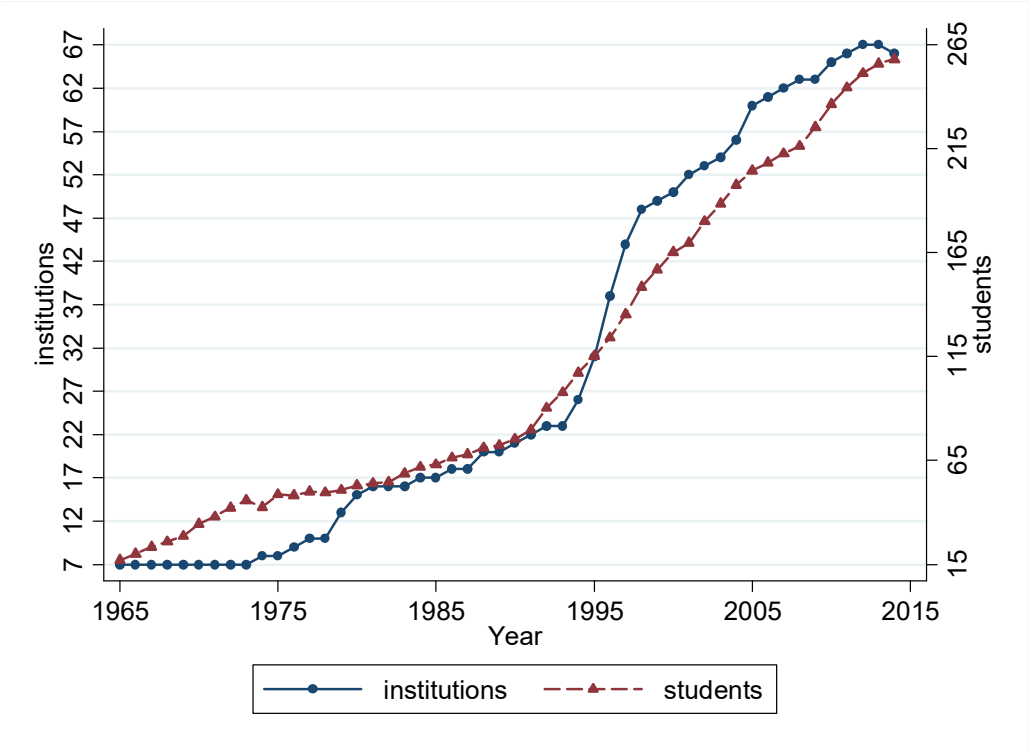
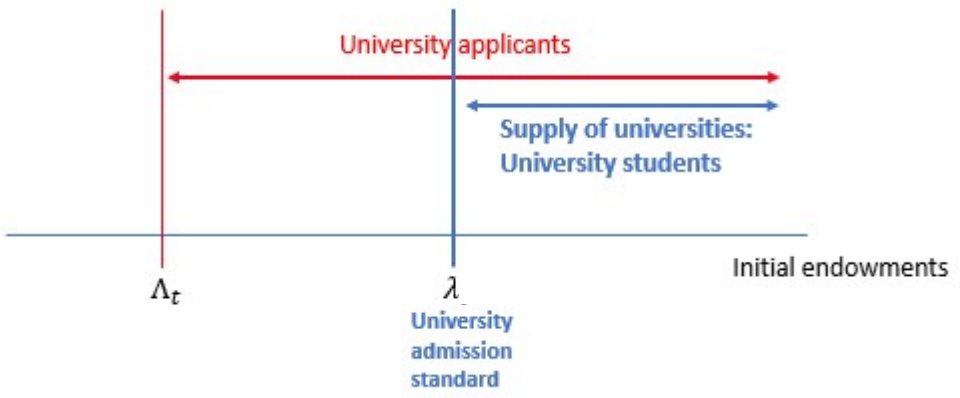
Figure 1: Higher Education Institutions and Students in Israel, 1965-2014



Note: The left axis denotes the number of HE institutions in Israel (marked in blue). HE institutions include Universities, academic Colleges and Colleges of education. The right axis denotes the number of students in thousands registered in HE institutions (marked in red). Student Register is based on files obtained from HE institutions.
Sources: Authors calculations based on the Israeli Council for HE (1994, p. 181) and (2016, p. 25), and the Statistical yearbook of Israel (2016, chapter 8.13).

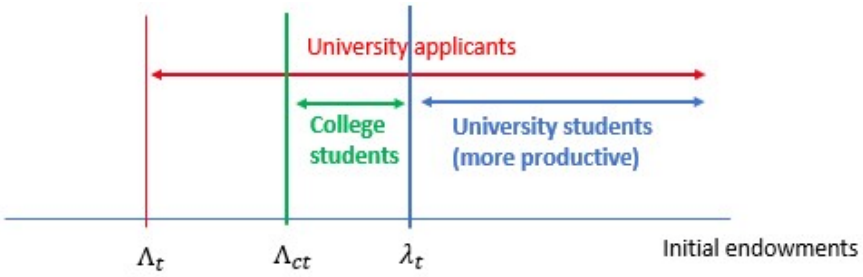
Figure 2: Selection of students, Universities only



Note: This figure illustrates the selection of students when only Universities exist. The University admission standard λ separates skilled workers (with higher education, also called 'University students')

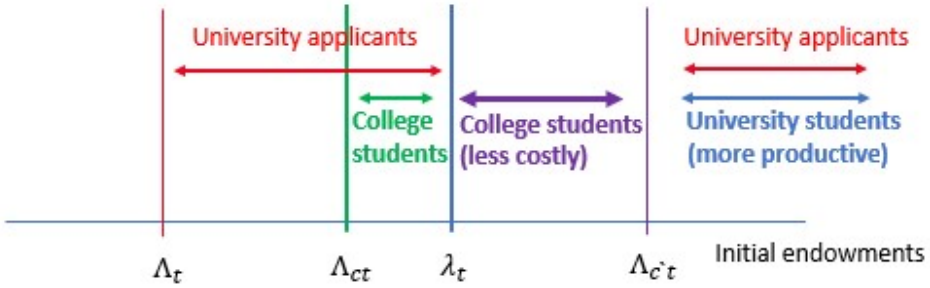
from low-skilled workers (with basic education). Students with initial endowments above Λ_t generate the demand for Universities.

Figure 3: Selection of students, Universities and Colleges



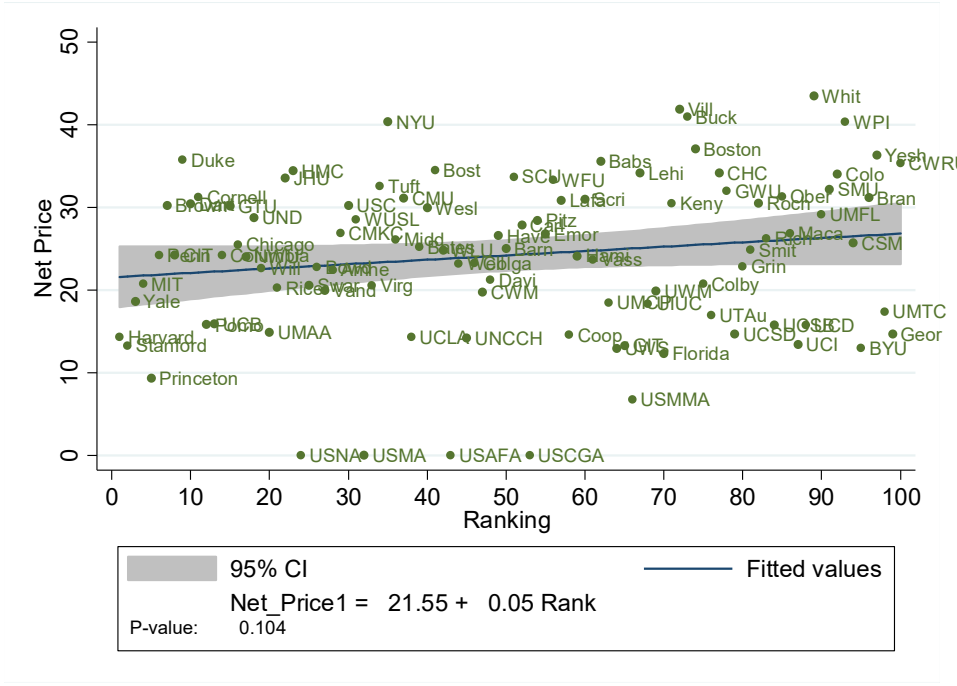
Note: This figure illustrates the selection of students when Universities and Colcolleges co-exist. Individuals with sufficiently low endowments (below Λ_{ct}) become low-skilled workers, the set $[\Lambda_{ct}, \lambda]$ attends Colleges, and students with initial endowments above λ attend Universities.

Figure 4: Universities and Colleges, subsidies targeted to highly-ranked students



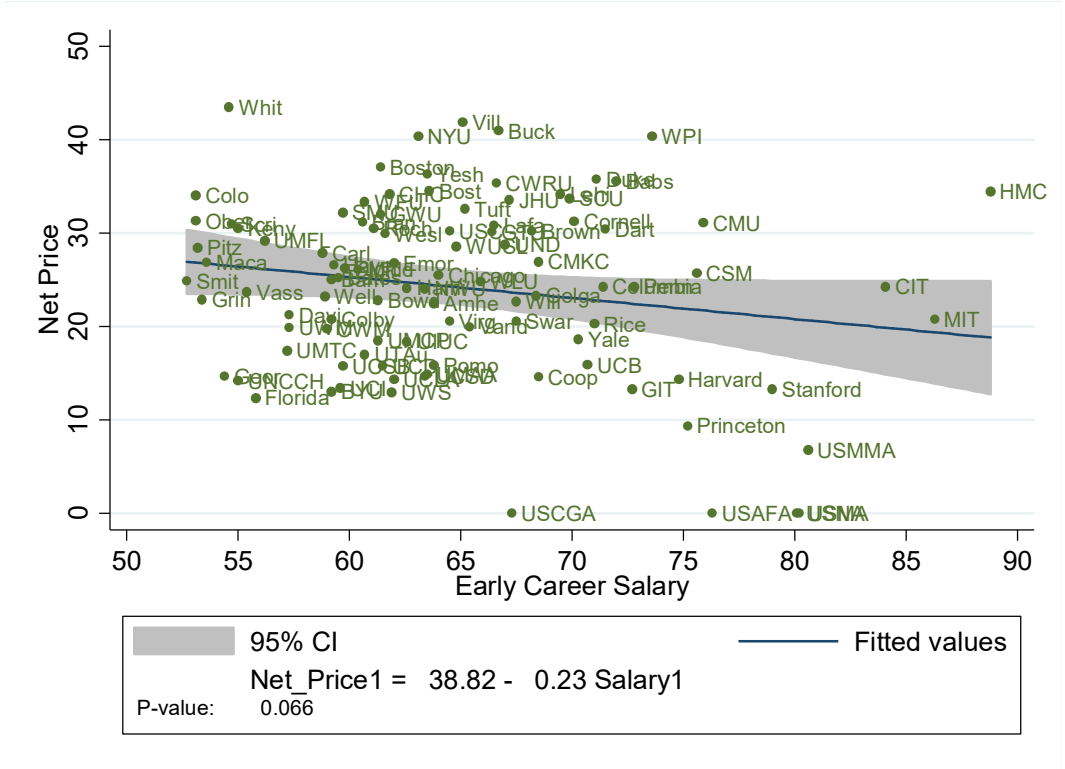
Note: When subsidies are targeted to the highly-ranked students, the selection of students is similar to figure 3 except for the set $[\lambda, \Lambda_{c't}]$ who may pursue College education as their first choice.

Figure 5a: Net price VS Ranking of the top 100 US Colleges and Universities in 2019



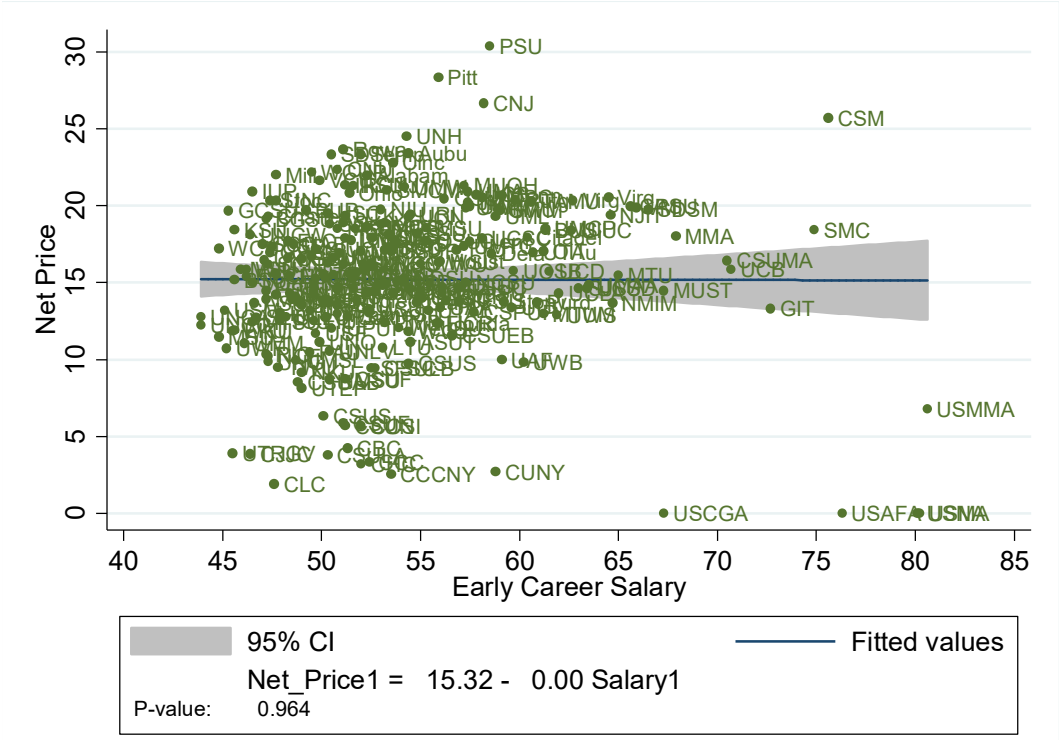
Source: Authors' calculations based on *Forbes America's top Colleges 2019.*
https://www.forbes.com/top-colleges/#4fe19b071987

Figure 5b: Net price VS Salary at the top 100 US Colleges and Universities in 2019



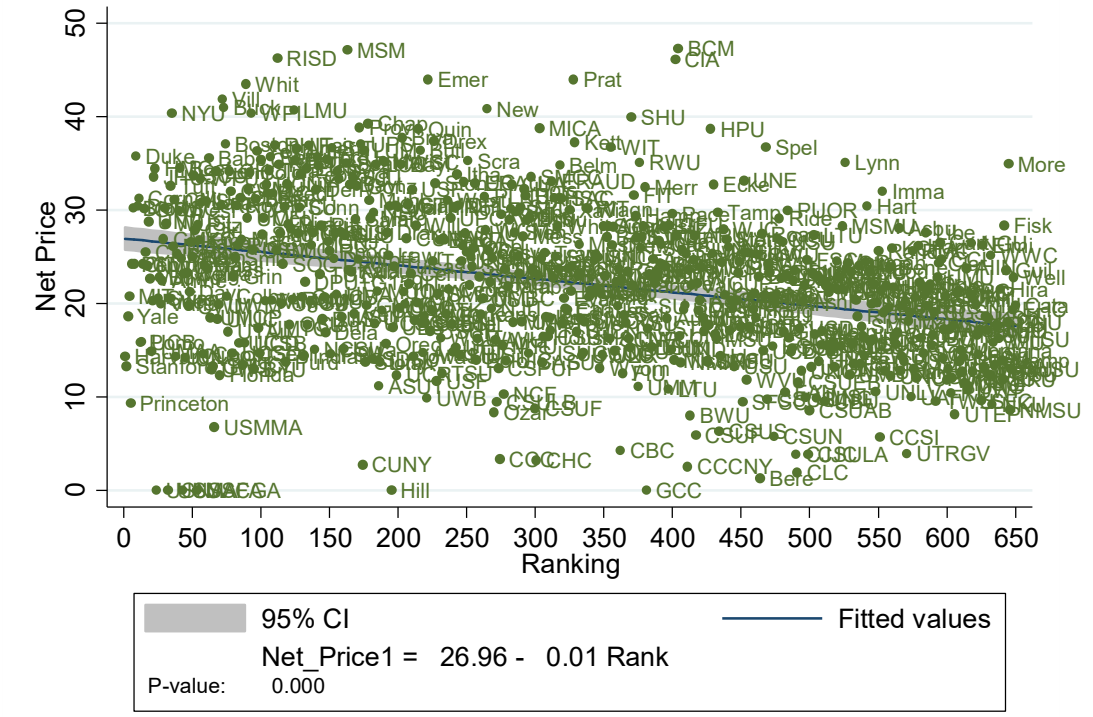
Source: Authors' calculations based on *Forbes America's top Colleges 2019.*
https://www.forbes.com/top-colleges/#4fe19b071987

Figure 5c: Net price VS Salary at the top 250 US Public Universities in 2019



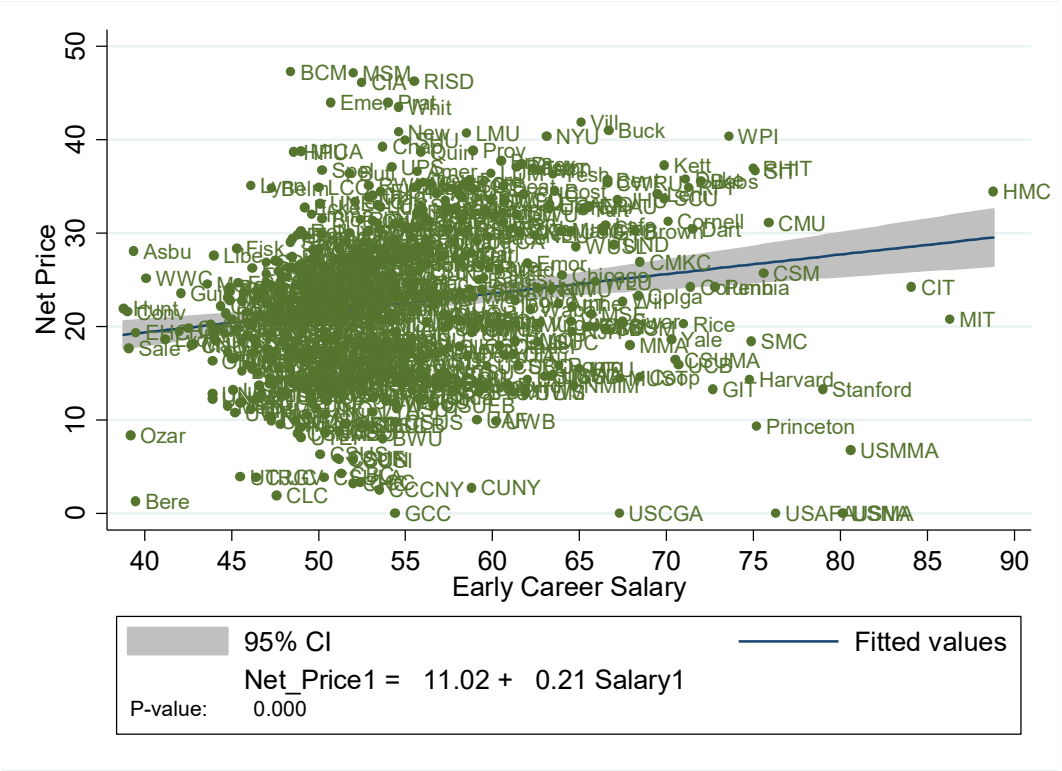
Source: Authors' calculations based on *Forbes America's top Colleges 2019.*
https://www.forbes.com/top-colleges/#4fe19b071987

Figure 5d: Net price VS Ranking at the top 650 US Colleges and Universities in 2019



Source: Authors' calculations based on *Forbes America's top Colleges 2019.*
https://www.forbes.com/top-colleges/#4fe19b071987

Figure 5e: Net price VS Salary at the top 650 US Colleges and Universities in 2019



Source: Authors' calculations based on *Forbes America's top Colleges 2019.*
https://www.forbes.com/top-colleges/#4fe19b071987

Appendix

Definition of the Equilibrium

Given K_0, H_0 , $\{(c_t^a(\omega), c_t^r(\omega), s_t(\omega), b_t(\omega), z_t(\omega)); w_t, r_t\}_{t=0}^{\infty}$ is a **competitive equilibrium** if:

(i) For each date *t*, given factor prices (r_t, w_t) and the public education policy (the share of basic education, γ, and the tax rate τ), the optimum under conditions (9)-(12) for household ω is $(c_t^a(\omega), c_t^r(\omega), s_t(\omega), b_t(\omega), z_t(\omega)) \geq 0$.

(ii) Given the aggregate production function, the wage rate of effective labor w_t is determined by the marginal product of (effective) human capital.

(iii) The education policy (γ and τ) is **feasible,** hence the government budget constraint in (8) holds at each date *t*.

After substituting all constraints, first order conditions with respect to $b_t(\omega)$ and $s_t(\omega)$ (assuming interior solutions) are:

(12)' $$\frac{c_t^a(\omega)}{y_{t+1}(\omega)} = \frac{\alpha_1}{\alpha_3}\frac{1}{(1+r_{t+1})}$$

(13)' $$\frac{c_t^a(\omega)}{c_t^r(\omega)} = \frac{\alpha_1}{\alpha_2}\frac{1}{(1+r_{t+1})}$$

From (12)' and (13)' we obtain that:

(14)' $$s_t(\omega) = \frac{\alpha_2}{\alpha_3}\frac{1}{(1+r_{t+1})}y_{t+1}(\omega)$$

Using (12)'-(14)' and the definitions of wage income in equations (3) and (4), we obtain the reduced-form income of agent ω who is either a low-skilled or a skilled worker (see Viaene and Zilcha, 2013):

$$y_{t+1}^l(\omega) = \left(\frac{\alpha_3}{\alpha_1+\alpha_2+\alpha_3}\right)(1+r_{t+1})\left\{\frac{(1-\tau)w_{t+1}}{(1+r_{t+1})}Z_{t+1}(\omega)X_t^{\xi} + y_t(\omega)\right\}$$

$$y_{t+1}^s(\omega) = \left(\frac{\alpha_3}{\alpha_1+\alpha_2+\alpha_3}\right)(1+r_{t+1})\left\{\frac{(1-\tau)w_{t+1}}{(1+r_{t+1})}B\,Z_{t+1}(\omega)X_t^{\xi} - (z^* - g_t) + y_t(\omega)\right\}$$

Note that we can solve fully for the competitive equilibrium path, given the parameters at date *t* (including $Z_{t+1}(\omega)$). Using the above two expressions, $y_{t+1}(\omega)$ can be calculated at date *t*, thus we can solve for the optimal $(c_t^a(\omega), c_t^r(\omega), s_t(\omega))$ using equations (12)'-(14)'. The two expressions for $y_{t+1}(\omega)$ exhibit an intergenerational persistence of incomes, that is:

$$\frac{\partial y_{t+1}^l(\omega)}{\partial y_t(\omega)} = \frac{\partial y_{t+1}^s(\omega)}{\partial y_t(\omega)} = \left(\frac{\alpha_3}{\alpha_1+\alpha_2+\alpha_3}\right)(1+r_{t+1})$$

It is increasing in altruism parameter α_3 and in the interest rate at the future date. Particularly, the persistence is similar for all households ω since α_3 is assumed to be the same for all families and $(1+r_{t+1})$ is given to all.

Proof of equation (13):

Parents apply to Universities if $y_{t+1}^s(\omega) > y_{t+1}^l(\omega) \Leftrightarrow U_t^s(\omega) > U_t^l(\omega)$ which implies:

$$(1-\tau)B\theta_t(\omega)h_t(\omega)^{\nu}X_t^{\xi}w_{t+1} - (1+r_{t+1})z_t > (1-\tau)\theta_t(\omega)h_t(\omega)^{\nu}X_t^{\xi}[w_{t+1} + (1+r_{t+1})mw_t]$$

Rearranging this inequality, the set of University students is given by *Eq.* (13)**.**

Proof of equation (16):

Parents apply to Colleges (if not accepted to Universities) if $y^c_{t+1}(\omega) > y^l_{t+1}(\omega) \Leftrightarrow U^c_t(\omega) > U^l_t(\omega)$, which implies:

$$(1-\tau)B_c\theta_t(\omega)h_t(\omega)^\nu X_t^\xi w_{t+1} - (1+r_{t+1})z_t > (1-\tau)\theta_t(\omega)h_t(\omega)^\nu X_t^\xi [w_{t+1} + (1+r_{t+1})mw_t]$$

Rearranging this inequality, the set of College students, C_t, is given by *Eq.* (17). ■

Proof of equation (17): Assume that subsidies are merit-based. Therefore, some students who are accepted to Universities, $Z_{t+1}(\omega) > \lambda$, are eligible for subsidies as College students, g_{ct} >0, but not as University students, $g_t = 0$. Their parents decide to apply to Colleges as their first-choice if

$$y^c_{t+1}(\omega) > y^u_{t+1}(\omega) \Leftrightarrow U^c_t(\omega) > U^u_t(\omega)$$

which implies:

$$(1-\tau)B_c\tilde{\theta}_t(\omega)h_t(\omega)^\nu X_t^\xi w_{t+1} - (1+r_{t+1})\left(z^* - g_{ct}\right) > (1-\tau)B\tilde{\theta}_t(\omega)h_t(\omega)^\nu X_t^\xi w_{t+1} - (1+r_{t+1})z^*$$

Rearranging this inequality yields *Eq.* (18). ■

Proof of Proposition 1: In the emergence of Colleges, the set of skilled workers, A_t, increases, because individuals with initial endowments $\left[\Lambda_{ct}, \lambda\right]$ at their youth period enrol to Colleges. At date *t*, the stock of human capital (*Eq.* (6)) remains unchanged because these students are not yet on the labor market. Specifically, denote the stock of human capital at date *t* in the case of 'Universities only' by H^U_t, and by H^{U+C}_t if Universities and Colleges co-exist. Then,

$$H^{U+C}_t = H^U_t$$

Consider now later periods. The emergence of Colleges has two effects. First, low-skilled workers join the skilled work force by enrolling to College: A_t increases but ~ A_t decreases by the same measure. Since we transfer low-skilled workers to the skilled labor force we obtain that $\int h_{t+1}(\omega)d\mu(\omega)$ increases. Second, more individuals induce their child to be a skilled worker (~ A_{t+1} decreases and A_{t+1} expands), and therefore $\int h_{t+2}(\omega)d\mu(\omega)$ increases). Specifically, the stock of human capital at date *t+1* that corresponds to the co-existence of Universities and Colleges equals

$$H^{U+C}_{t+1} = H^U_{t+1} + \int_{\Lambda_{ct}}^{\lambda} \left(h^c_{t+1}(\omega) - h^l_{t+1}(\omega)\right)d\mu(\omega) = H^U_{t+1} + (B_c - 1)\int_{\Lambda_{ct}}^{\lambda} h^l_{t+1}(\omega)d\mu(\omega)$$

$$> H^U_{t+1}$$

The last inequality is obtained using the human capital level of College graduates (*Eq.* (15)) and given that $B_c > 1$.). This process can be continued for the following periods. Moreover,

College admission standards, Λ_{ct}, keep declining over time, because the tax revenues keep increasing (augmenting the public funding for education), and therefore the stock of human capital keeps increasing over time because of the emergence of Colleges. Thus, our claim is proved. ■

Proof of Proposition 2: When the government subsidizes Colleges at date *t*, $g_{ct} = g_t > 0$, more individuals enrol to Colleges and A_t increases (because the subsidies reduce the out-of-pocket payments of College students). Then, our claim is proved in a similar way to proposition 1. ■