Tertiary Educational Choices: the United States versus Europe*

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Abstract

We study whether differences in productivity in the tertiary education sector and differences in educational and tax policies can explain differences in educational outcomes in the United States and Europe, especially lower European tertiary attainment and lower tertiary earnings premium. We calibrate a general equilibrium model with heterogeneous agents and dynasties which allows for schooling choice at the tertiary level.

We find that high European schooling subsidies combined with significantly lower productivity of the tertiary sector can account for the observed differences. Tertiary sector productivity is quantitatively more important than educational subsidies, which can explain only 14-20 percent of differences in tertiary attainment. On the other hand, higher educational subsidies relax credit constraints and lead to a more efficient allocation of skills at the tertiary level. The allocation of skills is, however, quite close to the first-best allocation of skills in both United States and Europe.

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1 Introduction

Educational policies and outcomes differ widely across developed countries. The differences are particularly striking when one looks at tertiary education in the United States and in Europe. We document three stylized facts about educational policies and educational systems: First, in the United States less than half of the costs of tertiary education is paid from public sources, while European countries finances almost all tertiary costs come from public sources. Second, the tertiary educational premium on earnings is significantly lower in Europe than in the United States. Third, the tertiary attainment rates are also lower in Europe than in the United States.

Those facts appear inconsistent with each other. A standard economic reasoning suggests that higher tertiary educational subsidies imply higher educational attainment which in turn lowers the tertiary educational premium. But that is inconsistent with the second and third stylized fact: Higher European subsidies are associated with lower educational attainment, and lower educational attainment is associated with lower educational premium. The goal of this paper is to explain this puzzle, and to find how much can be explained by productivity differences, and by differences in educational and tax policies.

We find that differences in in the productivity of the tertiary educational sector are able to explain most of the differences in the educational outcomes between the United States and Europe. We measure the productivity of the tertiary educational sector by the marginal rate of technical substitution between skilled (tertiary) and unskilled (secondary) labor when both types of labor are supplied at an equal amount. The productivity of the U.S. tertiary educational sector is 74% higher than in Germany, 73% higher in France, and 52% higher than in Great Britain. If Europe adopted U.S educational technology, European tertiary attainment would be almost the same as in the United States. In contrast, differences in educational policies can only explain a small fraction, about 14-20 percent, of the overall differences in educational outcomes. This is due to the general equilibrium effects that decrease the relative wages in the tertiary sector. However, we find that high European education subsidies generate a different skill distribution among the college educated: high skilled individuals are represented relatively more than low and medium skilled individuals. The allocation of skills is closely related to the importance of credit constraints. Higher educational subsidies relax credit constraints, and skew the allocation of skills at the tertiary level toward high skills.

We perform several policy experiments: in the first one the European countries adopt U.S. educational subsidies and costs; in the second one the European countries adopt

U.S. income tax; and in the third all countries adopt a flat income tac. Adoption of low U.S. educational subsidies decreases tertiary educational attainment and increases educational premium, but the effects are relatively small. For example, the tertiary attainment decreases between 1.6 percentage points (United Kingdom) and 2.7 percentage points (Germany). At the same time, the fraction of credit constrained households increases significantly. The combination of low educational subsidies and low productivity of the tertiary sector is thus especially adverse when one looks at the importance of credit constraints. If the European countries adopt U.S. income tax, which is less progressive, tertiary educational attainment increases, but the increase is again relatively small: from 1.2 percent age points in the United Kingdom to 2.6 percentage points in Germany. A flat tax goes a little further, and tertiary attainment increases from 2.3 percentage points in France to 5 percentage points in the United States. All the policy reforms, however, confirm that educational subsidies and tax policies only have a limited ability to change educational outcomes in the aggregate, but have more important distributional consequences.

To assess how important the differences in the allocation of skills are, we compare the equilibrium allocation to a first-best allocation where skills are, essentially, allocated on the basis of their comparative advantage: in our calibration, high skilled individuals have a comparative advantage in tertiary education over medium and low skill individuals. Somewhat surprisingly, the overall tertiary attainment is, in all countries, very close to the efficient tertiary attainment (obviously, the social planner takes the educational technology as given). For example, in the United States the efficient tertiary attainment is 37.9 percent, only 0.9 percent age points lower than the equilibrium one. Likewise, in Europe, the efficient tertiary attainment is no more than 0.6 percentage points away from the equilibrium one. We also compare the equilibrium skill composition at the tertiary level to the efficient one, and find that European countries are closer to the first-best allocation, with only about 6 percent of skills misallocated, while United States have about 9 percent of skills misallocated. Overall, however, the equilibrium skill composition at college is very close to the equilibrium one.

We abstract from the admission policies we study in another paper Boháček and Kapička (2012). There we model admission policies as skill-based lotteries applied to students who apply for admission. Here we assume that all students who wish to study find a school that admits them. We clear the educational market by introducing psychological cost of schooling for students of different skills. Positive psychological costs of schooling have been often used in the literature (Gallipoli, Meghir, and Violante (2010), Heckman, Lochner, and Taber (1999b) and others) to match the educational attainment to data. We find psychological costs such that the total attainment and the skill composition of enrolled students matches the U.S. data: The OECD (2006) reports total educational attainment of 39.1% of the population age 24 to 65, with 71.13% of enrolled students with high skill, 22.22% of medium skill, and 6.65% of low skill. Because of the high quality of U.S. data for skill (NLSY), we use the same psychological costs of schooling also for European simulations and analyze the implied differences between the United States and European countries. We find that the psychological costs of schooling in Europe are overall significantly lower, and in most cases, even negative. If one takes the psychological costs as an unexplained part of educational choices, it is puzzling why so many, not so few, people go to college in Europe.

1.1 Related Literature

The model we build extends the dynastic framework of Fuster (1999) and Fuster et al. (2003) by incorporating human capital decisions. The model features individuals that are heterogeneous in their age, skills and (endogenously) in their assets, schooling choice and consumption. Those individuals are altruistic, care about utility of their descendants, and make all decisions on a family level. This seems especially important for investments in education since they are typically made at early stages of life, parents are involved in those decisions, and often provide needed financial resources.

In order to quantitatively evaluate the model we use PSID, NLSY, and GSOEP data to estimate two key elements of the model. The first one are the age-earnings profiles. We differentiate them by education and skills. Skills are constant over one's lifetime and represent the observed heterogeneity in earnings conditional on education and age. We identify each individual in our sample with a particular skill level and estimate the intergenerational correlations in skills. The intergenerational correlations in skills are the second key element of the model, and are critical in matching the intergenerational correlations in the present value of earnings that are observed in the data.

By assuming that educational decisions are made at a family level the model is similar to Becker and Tomes (1986). Unlike them, however, we build a general equilibrium model. The importance of general equilibrium effects in evaluation of policy reforms has been stressed only recently, most notably by Heckman, Lochner, and Taber (1998). Educational reforms in a general equilibrium life-cycle framework have been studied first by Heckman, Lochner, and Taber (1999b) and Heckman, Lochner, and Taber (1999a), who consider the effects of an increase in educational subsidies. Their main focus is to determine the magnitude of general equilibrium effects (which appear to be large), rather than to analyze various educational policies in detail. Kryvtsov and Ueberfeldt

(2007), Lee (2005) and Abraham (2004) also analyze educational reforms in a general equilibrium life-cycle framework. Compared to all those papers, our value added is that we allow for dynastic framework with realistically chosen intergenerational persistence in skills and provide a much more comprehensive set of policy reforms. Compared to the last three papers, we use a carefully estimated heterogeneity in skills to evaluate distributional consequences of the educational reforms. In a parallel research, Gallipoli, Meghir, and Violante (2010) study various educational policies in a similar general equilibrium economy with intergenerational links without comparing the U.S. and European educational policies.

The paper is organized as follows. Next section describes the differences between European and U.S. educational systems. The model is introduced in Section 3. Section 4 characterizes the underlying stochastic process for skills. Section 5 calibrates the model. Benchmark results are reported in Section 6, and results from the reforms are reported in Section 7. Section 8 studies how efficient the educational outcomes are, while Section 9 studies intergenerational mobility in education. Section 10 concludes.

2 Empirical Evidence

In this section we document three differences in educational systems between United States and tree major European countries: France, Germany and United Kingdom. First, United States have significantly lower tertiary educational subsidies. The first part of Table 1 shows what fraction of the educational costs is financed from public sources. We define the costs of education to include public and private expenditures on educational institutions and public expenditures on education outside educational institutions. [1] Primary and secondary schooling is almost fully subsidized in all the countries. There is, however, a significant difference between United States and European countries at the tertiary level. In the United States, only 47.7% of the costs is paid by the government. In contrast, Europeans pay almost all the costs from public sources. The subsidy rate ranges from 76.3% in United Kingdom to 89.1% in Germany. In Denmark, Finland and Greece, not included in Table 1, the fraction is even higher and equals 97%.

Second, as the second panel of Table 1 shows, United States have higher educational attainment than the European countries. In the United States, 39.1% of the population between ages 25 and 64 has tertiary education. In Europe, this fraction is significantly smaller: It ranges from only 23.9% in France to 29.0% in Sweden.

[1] The costs of education do not include private spending on education outside of educational institutions, e.g. living costs paid by parents (because the data are not available), as well as foregone earnings.

Table 1: Educational Policies and Attainment: U.S. and Europe

		Europe		
	U.S.	France	Germany	U.K.
Publicly Financed Costs (% of Total Costs)				
Primary & Secondary	0.919	0.941	0.828	0.865
Tertiary	0.477	0.847	0.891	0.763
Educational Attainment				
Primary & Secondary	0.609	0.761	0.751	0.710
Tertiary	0.391	0.239	0.249	0.290
Tertiary Earnings Premium				
	1.720	1.530	1.580	1.470
Total Expenditures on Education (% of GDP per capita)				
Primary	0.224	0.179	0.174	0.206
Secondary	0.259	0.314	0.270	0.257
Tertiary	0.709	0.405	0.496	0.514
Public Expenditures on Education (% of GDP)				
	0.057	0.059	0.047	0.054

Notes: Educational attainment is for ages 25-64. Tertiary earnings premium are average earnings of college graduated divided by the average earnings of individuals with secondary education for age 25-64. Total expenditures on education are public plus private. See Appendix B for data sources.

It may be argued that the educational attainment among 25 to 64 year olds may overemphasize the differences, because the educational attainment in Europe has been catching up with United States in the recent decades. But the conclusion that United States tend to have higher educational attainment does not change if one looks only at younger cohorts. For instance, the educational attainment in the age range between ages 25 and 34 is higher in Europe but stays the same in the United States. However, in all three European countries the educational attainment is still lower than in the United States, the highest being in France with 38%.

Third, tertiary educational premia are higher in the United States than in Europe. The third panel of Table 1 reports the tertiary earnings premium. We define the tertiary earnings premium as the average earnings of college graduates divided by the average earnings of individuals with secondary education for age 25-64. The data are taken directly from Table A9.1a of OECD (2006).[2] On average, people with tertiary education in the United States earn 73.0% more than people with only secondary education. This is a significantly higher tertiary educational premium than in all the European countries we look at. The educational premium in Europe ranges from only 47% in the United Kingdom to 58% in Germany.[3]

Fourth, while United States have higher tertiary educational premium, they also tend to have higher costs of tertiary education. The costs, measured as the expenditures per student as a fraction of GDP per capita, are shown in the fourth panel of Table 1. The costs are comparable at primary and secondary level, but are significantly higher in the United States at the tertiary level: the U.S. costs per student are 70.9% of GDP per capita, while in Europe they are only around 50% of GDP per capita. The differences are even more pronounced in absolute levels. They are generally reflected in the total costs as a fraction of GDP, as reported in the last panel of Table 1.

[2]For the United States, Germany and United Kingdom we could also use available national panel data sets - Panel Study of Income Dynamics (PSID) data for the United States, the German Socio-Economic Panel (GSOEP) for Germany and the British Household Panel Survey (BHPS) for United Kingdom - to compute the earnings premium from that. The resulting number are similar.

[3]It is well known that students in the United States do worse in various assessments of student performance than their European counterparts. For instance, OECD (2006) reports the mathematics performance in the OECD's Programme for International Student Assessment (PISA) tests of 15 year olds. The United States have the worst mean scores out of all countries in Table 1. But what ultimately matters for the quality of schooling systems is the ability to translate knowledge into the ability to generate earnings. As the educational premia show, European countries are at a disadvantage here.

3 The Model

We consider three overlapping generations of grandparents, parents and children. They constitute a single decision unit, pool their resources, and maximize the same objective function at the time when their lives overlap. This decision unit is called “a household”. A dynasty is a family line of ancestors and descendants.

Preferences. A dynasty cares about the utility of all its members. The preferences over a sequence of consumption per person $\{c_t\}_{t\geq 0}$ and a psychological cost of schooling are given by

$$E_0 \sum_{t=0}^{\infty} \left(\beta(1+\gamma)^{1-\sigma}\right)^t \left(N_t \frac{c_t^{1-\sigma}}{1-\sigma} - N_t^c \kappa_t\right), \qquad 0 < \beta < 1,$$

where β is discount factor, γ is technology growth rate, and N_t is dynasty size, which is stochastic and is described later. We abstract from the disutility of labor but include the psychological cost of attending college κ_t for N_t^c members of the dynasty enrolled rolled in college. Thee psychological costs will be described in detail later. They are important for matching the variation of schooling across people within a country and will be used for obtaining the enrollment and its distribution across individual with different skills.

Timing. A model period is 5 years. Each individual is born at age zero and lives no more than 90 years. The lifespan of an individual is divided into three stages of life, each of them equal to $T = 6$ model periods. The first stage in model periods $j = 1, \ldots, T$ (actual age 0 to 29 years) is youth, and an individual in this stage is called a son. While primary and secondary level of education is compulsory, the family decides whether a son should work after the secondary level, or continue to the tertiary level. In the second stage in model periods $j = T+1, \ldots, 2T$, the person is an adult (actual age 30 to 59), and will be called a father. The father spends all his time working. In the last stage in model periods $j = 2T+1, \ldots, 3T$, the person is called a grandfather (actual age 60 to 89), and will be retired from period $j_R = 2T+2$ (actual age 65). The age of a household is indexed by the age of the sons, $j = 1, \ldots, T$.

The population grows exogenously at rate $n > 0$. Following Fuster et al. (2003), a household consists of $m = (1+n)^T$ sons, one father, and m^{-1} grandfathers. Each period, household members face a probability of dying. The probability of surviving between age j and $j+1$ is given by $\hat{\psi}_j$.

A timeline for a typical household is depicted in Figure 1. Age-1 household consists of m newborn sons, father of age $T+1$ (calendar age 30), and m^{-1} grandfathers of age $2T+1$ (calendar age 60). Age-T household consists of m sons of age T (calendar age

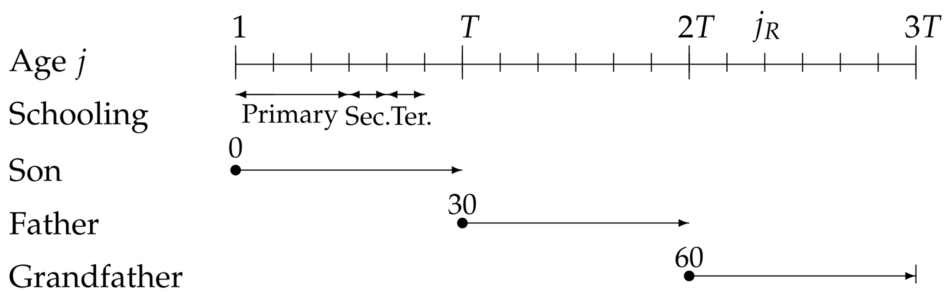


Figure 1: Timeline

25), father of age $2T$ (calendar age 55), and m^{-1} grandfathers of age $3T$ (calendar age 85). If at the end of period T the son is still alive, the household splits into m new age-1 households, each with m newborn sons, one father (one of the m sons), and m^{-1} grandfathers (out of one father). All former grandfathers die with certainty at this time. If a son dies before age T then the dynasty is broken at some point because no new child can be born. When the dynasty dies out, it is replaced by a new dynasty with zero assets.

Age-Earnings Profiles. Productivity of an individual is given by the age-earnings profile $\{\varepsilon_j(h,z)\}_{j=1}^{3T}$. The age-earnings profile depends on the skill of an individual and on his human capital. The age-efficiency profile is zero for retirees $(j \geq j_R)$.

There are three levels of human capital, $h \in H = \{\overline{h}_0, \overline{h}_S, \overline{h}_T\}$. They correspond to a human capital level before secondary schooling level was obtained, and to the secondary and tertiary schooling level. The secondary schooling level will be achieved in period $j = 4$ (age 15-19). The college human capital level $\overline{h}_T$ can be achieved in period $j = 5$ (age 20-24). In order to focus on tertiary schooling decisions it is compulsory to obtain obtain primary and secondary schooling level. It is also assumed that schooling is exclusive so that a person who attends a school cannot simultaneously work and the decision to start working is irreversible: once a person starts working, he cannot go back to school. The education is thus completed in period $j = 5$ (age 20-24) at the latest, and the human capital of an individual is constant from then on until the person dies.

The idiosyncratic skill level takes four possible values: zero, low, medium, and high, $z \in Z = \{0, \overline{z}_L, \overline{z}_M, \overline{z}_H\}$, where zero skill denotes a deceased individual. Skills are exogenous and, conditionally on being alive, constant for the whole lifespan of an individual. In addition, the skill of a son is partially inherited from its father in the following way. If a son survives to age T, he becomes a father, and all his m children share the same skill z^s which follows a first-order Markov process,

$$Q(\bar{z}_i, \bar{z}_j) = \text{Prob}(z^s = \bar{z}_i, | \, z^f = \bar{z}_j), \qquad i, j \in (L, M, H),$$

where z^f is the skill of their father. Note that all newborns inside a single household have the same skills which may be different from that of their cousins in the other households in the same dynasty.

Household Dynamics. In what follows, we will define $h = (h^s, h^f, h^g) \in H^3$ to be a collection of household members' human capital levels, and $z = (z^s, z^f, z^g) \in Z^3$ to be their skills. The state of a household of a given age is completely described by vectors h and z, and by household assets a. We assume that households face no-borrowing credit constraints, and so $a \geq 0$.

Based on individual survival probabilities $\hat{\psi}$, and on the transition matrix Q, we can completely summarize the skill dynamics of the household by a function $\psi_j(z', z)$, $j = 1 \ldots T$, that defines the conditional probability of the family having a skill profile z' next period given z. We also define three functions $\phi_s(z^s)$, $\phi_f(z^f)$ and $\phi_g(z^g)$ that denote the size of each generation within the dynasty: $\phi_s(z^s) = m$ if sons are alive and zero otherwise, $\phi_f(z^f) = 1$ if father is alive and zero otherwise, and $\phi_g(z^g) = m^{-1}$ if grandfathers are alive and zero otherwise. The total size of the living family is then given by $\phi(z)$ defined as

$$\phi(z) = \phi_s(z^s) + \phi_f(z^f) + \phi_g(z^g).$$

Cost of Schooling. The costs of schooling consist of forgone earnings, direct costs of schooling, and psychological costs. The direct costs are given by x_P for primary level, x_S for secondary level and x_T for tertiary level. Individuals who are attending a college suffer a psychological cost in terms of effort or dislike of the education process (see Heckman, Lochner, and Todd (2005)). The function $\kappa(z^s)$ represents the psychological cost of attending a college for a son with skill level z^s. Therefore, the period utility function for a household with $\phi_s(z^s)$ sons enrolled in college is

$$\phi(z) \frac{c^{1-\sigma}}{1-\sigma} - \phi_s(z^s) \kappa(z^s).$$

3.1 Government Policies

Government policies consists of schooling subsidies and of tax policies. The college subsidy is given by $d(z^s)$. Since the skills are assumed to be observed by the government, the college subsidy can possibly depend on a student's skill. The private direct cost $b(z^s)$ of college is then the difference between the total direct cost and the educational subsidy:

$$b(z^s) = x_T - d(z^s).$$

The direct cost of a secondary education is zero, since the secondary education is fully subsidized.

Tax instruments of the government include a flat tax rate on consumption τ_c, a flat tax rate on capital income τ_k, and a nonlinear tax schedule $t(I)$ on taxable earnings I. The government uses the tax revenue to finance its consumption G, social security benefits SS, as well as educational subsidies. The nonlinear tax $t(I)$ taxes the earnings of each household member individually. The total tax on earnings of the whole household in period j is

$$\begin{aligned} t_j(h, z, s) = \phi_s(z^s) t \left[\varepsilon_j(h^s, z^s)(1 - s) w_{z^s} - I_0 \right] + \phi_f(z^f) t \left[\varepsilon_{j+T}(h^f, z^f) w_{z^f} - I_0 \right] \\ + \phi_g(z^g) t \left[\varepsilon_{j+2T}(h^g, z^g) w_{z^g} - I_0 \right], \end{aligned} \tag{1}$$

where I_0 is a tax deduction and the variable $s \in \{0, 1\}$ indicates whether the sons attends a school $(s = 1)$ or not $(s = 0)$. The social security benefits $SS_j(h^g, z^g), j = j_R, \ldots, 3T$ are received by the retired grandfather, and depend, in general, on his human capital and skill.

3.2 Household's Problem

The individual state of an age-j household is given by (a, h, z), where a is the household's joint asset holdings. The after-tax earnings of an age-j household are given by[4]

$$e_j(h,z,s) = \begin{cases} \phi_s(z^s)\varepsilon_j(h^s,z^s)w_{h^s}(1-s) + \phi_f(z^f)\varepsilon_{j+T}(h^f,z^f)w_{h^f} + \phi_g(z^g)SS_{j+2T}(h^g,z^g) \\ \quad -t_j(h,z,s) \qquad\qquad \text{if } j+2T \geq j_R, \\ \phi_s(z^s)\varepsilon_j(h^s,z^s)(1-s)w_{h^s} + \phi_f(z^f)\varepsilon_{j+T}(h^f,z^f)w_{h^f} + \phi_g(z^g)\varepsilon_{j+2T}(h^g,z^g)w_{h^g} \\ \quad -t_j(h,z,s) \qquad\qquad \text{otherwise.} \end{cases}$$

3.2.1 Value Function for Age $j = 1\ldots, 4$

Let $V_j(a, h, z)$ be a steady state value function of an age-j household The value function satisfies for $j = 1, \ldots, 4$,

$$V_j(a,h,z) = \max_{c,a' \geq 0} \left\{ \phi(z)\frac{c^{1-\sigma}}{1-\sigma} + \beta(1+\gamma)^{1-\sigma} \sum_{z'} \psi_j(z',z)\, V_{j+1}(a',h',z') \right\}, \tag{2}$$

subject to the budget constraint

$$(1-\tau_c)\phi(z)c + \phi_s(z^s)\, b(z^s) + (1+\gamma)a' = (1+(1-\tau_k)r)a + e_j(h,z,1) + \phi(z)\xi, \tag{3}$$

where c is consumption of each household member, a' are savings of the whole household, and ξ is a lump-sum transfer from accidental bequests from deceased dynasties that are distributed by the government. Finally, h' is equal to h in periods 1, 2, 3, and to $(\overline{h}_S, h^f, h^g)$ in period 4, reflecting the fact that the son obtains the secondary educational level $\overline{h}_S$ at the end of period 4.

3.2.2 Value Function for Age $j = 5$ (College Choice)

In period $j = 5$ the household can choose whether the son attends college. Denote $\hat{V}_j(a, h, z; s)$ to be the value of making a schooling decision $s \in \{0, 1\}$. The value function

[4]There are households in which both father and grandfather have died and sons must be supported by the government during their compulsory education. We assume that the support for each orphan son equals the average earnings of a low-skill father with secondary education. This government expenditure is included in its exogenous consumption, G. It is a minor detail in the model and is not further specified in the budget constraints or in the definition of equilibrium.

is given by

$$V_j(a,h,z) = \max_{s\in\{0,1\}} \hat{V}_j(a,h,z;s). \tag{4}$$

The value of not attending college is given by

$$\hat{V}_j(a,h,z;0) = \max_{c,a'\geq 0} \left\{ \phi(z)\frac{c^{1-\sigma}}{1-\sigma} + \beta(1+\gamma)^{1-\sigma} \sum_{z'} \psi_j(z',z)\, V_{j+1}(a',h,z') \right\},$$

subject to

$$(1+\tau_c)\phi(z)c + (1+\gamma)a' = (1+(1-\tau_k)r)a + e_j(h,z,0) + \phi(z)\xi. \tag{5}$$

Note that the next period human capital h' held at the same level $h' = h$. If the son attends college the value function is given by

$$\hat{V}_j(a,h,z;1) = \max_{c,a'\geq 0} \left\{ \phi(z)\frac{c^{1-\sigma}}{1-\sigma} - \phi_s(z^s)\kappa(z^s) + \beta(1+\gamma)^{1-\sigma} \sum_{z'} \psi_j(z',z)\, V_{j+1}(a',h',z') \right\},$$

subject to

$$(1+\tau_c)\phi(z)c + s\,\phi_s(z^s)\,b(z^s) + (1+\gamma)a' = (1+(1-\tau_k)r)a + e_j(h,z,1) + \phi(z)\xi, \tag{6}$$

where $h' = (\overline{h}^T, h^f, h^g)$.

3.2.3 Value Function for Age $j = T$

At the end of period T, the household transforms itself into an age-1 household in the following way: the grandfathers reach the end of their life, fathers become grandfathers, sons become fathers, and new sons are born. Since there is no schooling in period $j = T$, there is no cost of education of any form, and the value function V_T is given by

$$V_T(a,h,z) = \max_{c,a'\geq 0} \left\{ \phi(z)\frac{c^{1-\sigma}}{1-\sigma} + \beta(1+\gamma)^{1-\sigma} m \sum_{z'} V_1(a',h',z')\, \psi_T(z',z) \right\}, \tag{7}$$

subject to the budget constraint

$$(1-\tau_c)\phi(z)c + m(1+\gamma)a' = (1+(1-\tau_k)r)a + e_T(h,z,0) + \phi(z)\xi. \tag{8}$$

The vector of skills of the new age-1 household is given by $z' = (z^{s\prime}, z^s, z^f)$, where $z^{s\prime}$ is newborns' skill draw. The vector of human capital levels of the new age-1 household is given by $h' = (\bar{h}_0, h^s, h^f)$. In words, the newborn sons partially inherit their father's skill and start with the basic human capital level, while each of the current sons becomes a father and the current father becomes grandfather, both keeping their skills and human capital.

3.3 Aggregate Production Function

We assume that the aggregate production technology is represented by a standard Cobb-Douglas production function,

$$F(K, AL) = K^\alpha (AL)^{1-\alpha},$$

where K is aggregate capital stock with rate of depreciation $\delta \in (0,1)$, A is technology level growing at an exogenous rate γ, and L is a constant returns to scale aggregator of secondary and tertiary aggregate human capital H_S and H_T.[5] The aggregator is given by

$$L(H_S, H_T) = \left[(1-\theta)H_S^\rho + \theta H_T^\rho\right]^{\frac{1}{\rho}}. \tag{9}$$

Different human capital levels are therefore imperfect substitutes, with the elasticity of substitution between them given by $1/(1-\rho)$. The share parameter θ determines the marginal rate of technical substitution between skilled and unskilled labor. We also express the relative productivity of the tertiary sector by $\zeta = \theta/(1-\theta)$.[6]

Competition among firms results in prices of inputs being equal to their marginal products,

$$r = F_K(K, AL) - \delta, \tag{10}$$

$$w_i = AF_L(K, AL)L_{H_i}(H_S, H_T), \ \ i = S, T. \tag{11}$$

3.4 Recursive Competitive Equilibrium

Let $(a, h, z) \in (A \times H^3 \times Z^3)$ be an individual household's state vector. The optimal policy functions are given by $\{a_j, h_j, s_j\}_{j=1}^T$, where we define $s_j = 1$ in periods 1 to 4 and

[5]Since secondary schooling level is compulsory, no individual ends up with primary schooling level.

[6]We omit time subscripts on the quantities because we will only consider steady state allocations.

$s_j = 0$ in period 6, and $h_j \in H^3$ denotes the vector of next period human capital for the whole household. Let $\{\lambda_j\}_{j=1}^{T}$ be an age-dependent measure of households over the individual states. Its law of motion for each $(a', h', z') \in (A \times H^3 \times Z^3)$ and for $j = 1, 2, 3$, is

$$\lambda_{j+1}(a', h', z') = \sum_{\{(a,h,z):a'=a_j(a,h,z),h'=h_j(a,h,z)\}} \psi_j(z', z)\, \lambda_j(a, h, z).$$

For $j = 4, 5$, the law of motion is given by

$$\begin{aligned}\lambda_{j+1}(a', h', z') = & \sum_{\{(a,h,z):a'=a_j(a,h,z;1)\}} s(a, h, z)\, \psi_j(z', z)\, \lambda_j(a, h, z) \\ & + \sum_{\{(a,h,z):a'=a_j(a,h,z;0)\}} (1 - s(a, h, z))\; \psi_j(z', z)\, \lambda_j(a, h, z).\end{aligned}$$

The law of motion for the measure of age-1 households, for each $(a', h', z') \in (A \times H^3 \times Z^3)$ with $z' = (z^{s\prime}, z^s, z^f)$, is, for $h' = (\bar{h}_0, h^s, h^f)$

$$\lambda_1(a', h', z') = \sum_{\{(a,h,z):a'=a_T(a,h,z)\}} \phi_T(z^s)\, \psi_T(z', z)\, \lambda_T(a, h, z),$$

and zero otherwise. Broken dynasties are replaced by newborn dynasties with zero assets and with a representative composition of skills and human capital of $j = 1$ households.

In Appendix A we present the formal definition of the stationary recursive competitive equilibrium. Here we present its brief outline.

Stationary Recursive Competitive Equilibrium *Given schooling subsidies, tax policies, cost of schooling, and government consumption, a stationary recursive competitive equilibrium is a set of value functions, household policy functions, factor prices, accidental bequest transfers, and measures of households such that: 1) households optimize; 2) prices are competitive; 3) aggregate levels clear; 4) the measures are time invariant; 5) the government's budget is balanced; and 6) the aggregate feasibility constraint holds.*

4 Stochastic Process for Skills

To quantitatively evaluate the model, we estimate the distribution of skills over the life-cycle as well as the intergenerational correlations in skills. Due to the lack of appropriate national data sources for France, we compute the age-earning profiles only for United States, Germany and United Kingdom, and assume that French age-earning profiles are identical to German ones. The distribution of idiosyncratic shocks, as well as the intergenerational correlations in skills are estimated only for the United States, and will be assumed to be identical in all European countries.

Age-Earning Profiles

Let $y^h_{\iota at}$ be the logarithm of labor earnings of an individual ι who has attained education level h and has age a in period t. We decompose the earnings into a deterministic component that depends only on age and education b^h_a, a deterministic component that depends only on time and education v^h_t, and an idiosyncratic residual component $u^h_{\iota t}$:[7]

$$y^h_{\iota at} = b^h_a + v^h_t + u^h_{\iota t}. \tag{12}$$

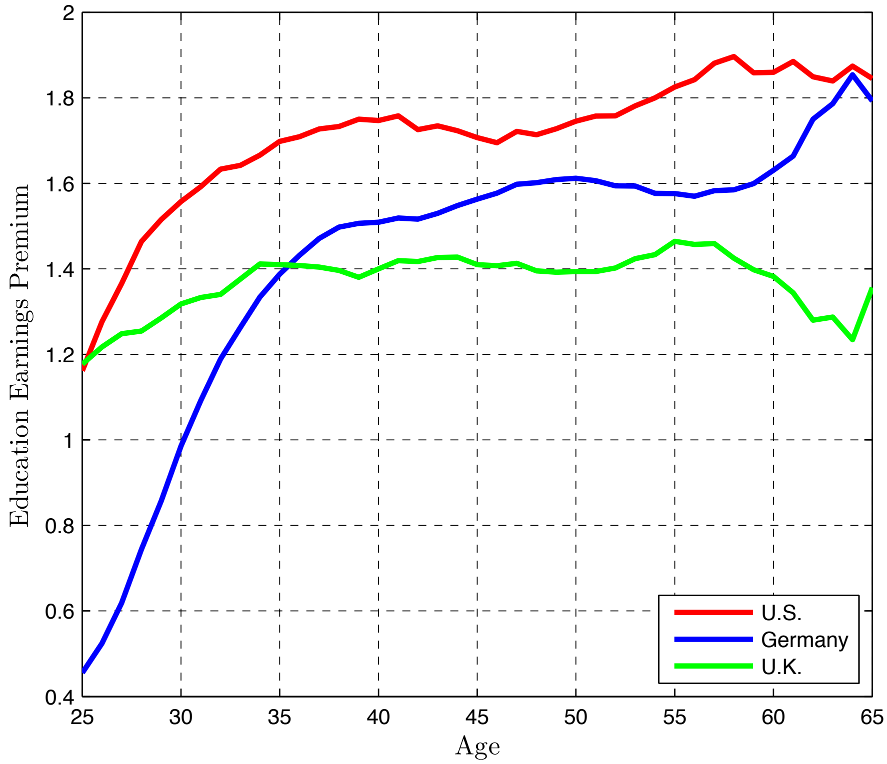
For each educational level we run a regression of $y^h_{\iota at}$ on the full set of age and time dummies and estimate the coefficients b^h_a and v^h_t. We use PSID data for the United States, BHPS data for United Kingdom and GSOEP data for Germany. [8]

In Figure 2 we report the tertiary educational premium, which is just the coefficient $e^{b^T_a - b^S_a}$. The figure shows that the educational premium is the highest in the United States at all ages. The average educational premium is 1.730 for the United States, 1.390 for Germany and 1.457 for the United Kingdom. Those estimates are similar to the values reported in Table 1, although the data sources are quite different.

The differences in the slope of the intertemporal profile are significant as well. College educated individuals in the United States and United Kingdom start earning more than individuals without college immediately at age 25. On the other hand, the tertiary premium in Germany is initially negative and college graduates only overtake their less educated counterparts only at age 30. In United Kingdom the tertiary premium is relatively flat for the whole life-cycle.

[7]We control for the time effects but not for cohort effects, consistently with most of the literature. Both cohort effects and time effects cannot be identified separately (see e.g. Heathcote, Storesletten, and Violante (2005)).

[8]Our data selection is consistent with Heathcote, Perri, and Violante (2010) for United States, by Fuchs-Schuendeln, Krueger, and Sommer (2010) for Germany, and by Blundell and Etheridge (2010) for Great Britain. All three papers are a part of a special issue of the Review of Economic Dynamics on "Cross Sectional Facts for Macroeconomists" in January 2010. This issue contains a systematic analysis of various cross-sectional facts for selected countries, and all the authors have made an effort to make their dataset comparable across countries. See Appendix B for details.



Source: PSID, GSOEP.

Figure 2: Tertiary Earnings Premium by Age and Education

Earning Shocks

The next step is to characterize the distribution of the idiosyncratic earning shocks. The estimation of the earning shocks is complicated by the well-known "ability bias": more skilled people will typically choose more education, and so $u^h_{\iota t}$ cannot be taken as an approximation of the shock distribution. Instead we obtain the distribution of residual earning shocks as follows. We decompose the residual earnings $u^h_{\iota t}$ into an intercept ϕ_0, fixed effect component that depends on permanent individual ability z_ι, its gradient ϕ^h, and a residual iid error term $\epsilon_{\iota t}$:

$$u^h_{\iota t} = \phi_0 + \phi^h z_\iota + \epsilon_{\iota t}. \tag{13}$$

The ability gradient ϕ^h determines the impact of the ability z_ι on individual's earnings, and potentially varies with education. To deal with the ability bias problem we assume, as in Gallipoli, Meghir, and Violante (2010), that ability can be approximated for the

Table 2: U.S. Skill Distribution

Skill	Low	Medium	High
Skill Distribution			
mean	-0.239	0.035	0.210
s.d.	0.124	0.053	0.052
Skill Composition by Education			
Secondary	0.423	0.373	0.203
Tertiary	0.066	0.222	0.711

United States by an *observable* characteristics, the Armed Force Qualification Test (AFQT) score. The NLSY79 panel data contain the information about AFQT scores, as well as about earnings. We filter out the age effects from individual earnings in NLSY79 to obtain the residual earnings u_{it}^h and estimate the intercept ϕ_0 and the ability gradients ϕ^h by regressing u_{it}^h on the raw AFQT score for each education level.[9] The estimated ability gradients are $\phi^S = 0.906$ and $\phi^T = 0.911$. That indicates that the gain from having higher skills is approximately the same for both educational levels, with the complementarity between skills and education being only slightly positive.

We divide the distribution of the raw AFQT scores into three bins of equal frequencies and associated each bin with a skill level. The first panel of Table 2 reports the resulting distribution of skills. The distribution is slightly right-skewed and more dispersed at the bottom. The second panel of Table 2 shows that the ability bias is indeed significant. 71.1% of people with college have high skill, while only 6.6% have low skill.

Intergenerational Correlations

To estimate the intergenerational correlations in skills for United States, we again follow the procedure in Gallipoli, Meghir, and Violante (2010).[10] We approximate mother's ability by her AFQT score. For children, NLSY79 reports their Peabody Individual Achievement Test (PIAT) Math test scores. The PIAT test is among the most widely used assessments of academic achievement. We split both mother and children into three groups of equal size, and compute, conditional on mother's score, the fractions of

[9]Our estimation differs from the one in Gallipoli, Meghir, and Violante (2010) in three ways. First, we look at earnings and not at wages. Second, we use a full set of dummies to estimate the age effects, rather than a polynomial in age. Third, we use two education levels instead of three.

[10]Our estimates differ from the ones in Gallipoli, Meghir, and Violante (2010) only in one way: we work with three ability level rather than five, to fit our model structure.

Table 3: U.S. Transition Matrix for Skills

Parent's Skill	Child's Skill		
	Low	Medium	High
Low	0.568	0.293	0.139
Medium	0.312	0.386	0.302
High	0.155	0.320	0.525

children in each of the three groups. This creates the transition matrix.

The intergenerational correlations in skills, shown in Table 3, have the expected pattern: child's skills are strongly positively correlated with parent's skills. For instance, 56.7% of low skilled parents have a low skilled child, while only 15.5% of high skilled parents have a low skilled child. Or, only 13.9% of low skilled parents have a high skilled child, while 52.6% of high skilled parents have a high skilled child.

5 Calibration

We calibrate the economy for the United States, and for the three European countries, France, Germany and United Kingdom. Some of the parameters are country specific; some of them are common to all countries.

The following parameters are common to all countries, and are reported in Table 4. We set the coefficient of relative risk aversion σ to 2, and the discount factor β to 0.9889 annually, to match the annual capital output ratio of 3.2 in the United States. The capital share α is set to 0.34. The elasticity of substitution between various human capital levels is set to 2, which implies that ρ is 0.5. This value is in the middle of the estimates in Gallipoli, Meghir, and Violante (2010), who estimate it to be between 0.32 and 0.68. The depreciation rate δ is 0.04, the annual technology growth rate is 1.65% and the population growth rate is 1.2% for all countries. Maximum lifetime is 90 years and we calibrate the survival probabilities $\hat{\psi}$ by using the mortality rates reported by Brown, Liebman, and Pollet (2002), who estimate them by age (25-100), sex, education and race using data from the National Longitudinal Mortality Survey. We aggregate the mortality rates by sex, race and education, using frequencies from the PSID sample.[11]

[11] Brown, Liebman, and Pollet (2002) consider three educational categories: people with less than high school, people with high school, but not with college, and people with at least college degree. This categorization is consistent with our definition of educational groups.

Table 4: Common Parameters

Population		
j_{3T}	18	Maximum lifetime (90 years)
j_R	14	Retirement age (65 years)
$\bar{n}$	0.012	Population growth rate U.S.
ψ		Survival probabilities
Utility		
β	0.9889	Annual discount factor
σ	2.0	Relative risk aversion
Production		
γ	0.0165	Annual technology growth
δ	0.04	Annual depreciation rate
α	0.34	Capital share
ρ	0.5	Elasticity of substitution

Note: the remaining parameters θ, κ, ε x, d, t are country specific.

The retirement age is 65 years.

The psychological costs κ are calibrated as follows. For the United States we choose κ to match both the tertiary educational attainment and the skill composition at the tertiary level (there are three values of κ to choose and three targets). This is possible since we know the distribution of skills at both secondary and tertiary level (Table 4). For other countries we do not know the skill distribution at the tertiary level, and so we adjust the psychological costs $\kappa(z)$ to match the educational attainment in each country (Table 1), by adding or subtracting a constant. The benchmark model will thus replicate the educational attainment for all countries, and the skill composition for the United States.[12]

We compute the coefficients $\varepsilon_j(h,z)$ from our estimates of the age-earning profiles and the ability gradients: $\ln \varepsilon_j(h,z) = b_j^h + \phi_0 + \phi^h z$. For the United States, Germany and United Kingdom, the coefficients b_j^h are the coefficients we reported in Figure 2. For France we set them equal to the estimates for Germany. The coefficients ϕ_0 and ϕ^h, and the values of z are, set equal to the estimates in Section 4 for all countries (the values of z are reported in the first line of Table 2). Thus, each skill level is represents one third of

[12]We also considered a version where the psychological costs for the European countries are multiplied by a constant, leaving the rations unchanged. This approach, is, however, problematic, because the constant might be negative, reversing relative psychological costs across skill levels.

a population. The intergenerational transition matrix in skills is set to the U.S. transition matrix estimated in Table 3, for all countries.

The share parameter θ measures the relative importance of the tertiary sector in the production function. This parameter is country specific, and is chosen to be such such that the equilibrium tertiary earnings premium in the model is equal to the tertiary earnings premium reported in the second panel of Table 2.

The costs of schooling $x(h_i)$ are set to replicate the costs per student as a fraction of GDP per capita reported in the fourth panel of Table 1. The schooling subsidies d are assumed to be independent of skills and are equal to the fraction of the costs that is publicly financed, as reported in the first panel of Table 1. The tax function $t(I)$ is taken to be such that the average tax is identical to the average labor wedge, as measured by OECD (2008). As for the tax deduction we find such a level that clears the government budget constraint in the benchmark steady state. The capital tax rate and the consumption tax rate are taken from from Uhlig and Trabandt (2009), and the replacement rate of retirement benefits is taken from OECD (2011). Government expenditures include expenditures on education, which are reported in Table 1, and other government expenditures. Details regarding tax and social security parameters, as well as government expenditures, are in Appendix B.

6 Benchmark Results

For each of the countries we compute the stationary equilibrium and report the main results in Table 5. In all cases, tertiary attainment and tertiary earnings premium are matched to country specific data, while the skill composition at tertiary level is only matched for the U.S. economy.

With respect to the educational sector, the results show two major differences between the United States and European countries. First, the productivity of the tertiary educational sector is significantly lower in Europe. The productivity of the tertiary educational sector is measured by the share parameter θ or, more explicitly, by the ratio

$$\zeta = \frac{\theta}{1-\theta},$$

which are the relative wages in the tertiary sector if the supply of labor in both the secondary and tertiary sector was normalized to one.[13] The parameter ζ thus measures

[13] It follows from (11) that relative wages in the tertiary sector are then $w_T/w_S = L_{H_T}(1,1)/L_{H_S}(1,1) = \zeta$.

Table 5: Benchmark Allocations and Prices

		Europe		
	U.S.	FRA	GER	U.K.
Capital	0.649	0.689	0.766	0.603
Output	0.207	0.196	0.203	0.187
Consumption	0.110	0.098	0.113	0.107
Tax Exemption	-0.176	0.092	0.083	0.037
θ	0.560	0.424	0.422	0.456
Education Premium	**1.730**	**1.447**	**1.398**	**1.453**
Tertiary Attainment	**0.388**	**0.243**	**0.256**	**0.293**
Psychological Cost of Tertiary Education by Skill				
Low	3.872	-0.694	-1.922	-2.827
Medium	5.041	0.475	-0.752	-1.658
High	3.355	-1.211	-2.439	-3.344
Tertiary Attainment Composition Across Skill Groups				
Low	**0.064**	0.065	0.062	0.055
Medium	**0.221**	0.062	0.058	0.051
High	**0.715**	0.874	0.880	0.894
Tertiary Attainment in Each Skill Group				
Low	0.071	0.045	0.046	0.046
Medium	0.259	0.045	0.045	0.045
High	0.867	0.663	0.702	0.813

Note: Each country has specific psycho costs based on level shift from U.S. psycho costs to match country total tertiary attainment. Country specific θ to match education premium. Attainment composition across skill groups is matched only in the U.S. economy. Outcomes in bold are matched to data in calibration.

relative productivity of the tertiary sector independent of the relative labor supply effects. It follows from the values in Table 5 that for the United States $\zeta = 1.272$, while for the European countries it is only 0.730 for Germany, 0.736 for France, and 0.838 for the United Kingdom. Even for the United Kingdom, the country with the highest ζ among the three European countries, the tertiary educational sector's productivity is only about two thirds of U.S. productivity. Europe has a low implied productivity of the tertiary sector primarily because of a combination of two factors: low tertiary earning premium, and relatively low supply of labor at a tertiary level. If tertiary productivity ζ was as high as in the United States, low tertiary labor supply would imply a much higher tertiary educational premium than what is observed in the data and, conversely, low tertiary educational premium could only be achieved with much higher tertiary labor supply than what is observed in the data. We will later study how the European countries would perform if they had the same production technology as the United States.

A second major difference is that the psychological costs of education are significantly lower in the European countries. Low psychological costs are needed to match the tertiary attainment. Europeans face a relatively unproductive tertiary sector (low values of ζ), and so the returns from tertiary education are small. If the psychological costs of education were as large as in the United States, tertiary attainment would be even lower in Europe than what is observed in the data. Recall that we adjust the psychological costs for the European countries by subtracting a constant from the psychological costs for all three skill levels, leaving relative differences the same as in the United States. The adjustments to the psychological costs are significant: for Germany they decrease by 4.566, for France by 5.794, and for United Kingdom by 6.699. To get a sense of those magnitudes we computed the percentage decrease in consumption that an average college attending household in the United States would be willing to forgo in each period in order to face lower psychological costs. For France, the required decrease is 5.4 percent of consumption for high skilled, 4.9 percent of consumption for medium skilled, and 5.8 percent of consumption for low skilled. The corresponding costs are even bigger for Germany and United Kingdom, in the order of 6-8 percent. Also note that for Germany and United Kingdom the psychological costs become significantly negative, while for France they are positive for medium skills, but negative otherwise. To the extent that psychological costs are a measure of unexplained incentives to go to college, the puzzle in the European countries is the opposite to the one in the United States: while in the United States it is puzzling why so few people go to college, in Europe it is puzzling why so many people go to college. Note also that large educational subsidies are able to mitigate the effect of low productivity of the tertiary sector, but only partially. They are not big enough to explain large tertiary attainment in Europe by themselves.

The distribution of psychological costs across skill levels in the United States is calibrated to match the observed distribution of skill levels at college in Table 2. The resulting psychological costs are non monotone across skills. Medium skilled agents face the highest psychological costs, while high skilled agents face the lowest costs. This model is thus calibrated so that 71.5% of college educated individuals are high skilled, and only 6.4% are low skilled. In Europe the resulting fraction of college educated individuals that are high skilled is higher, ranging from 87.4% in France to 89.4% in the United Kingdom.

Sensitivity Analysis. In Appendix C we simulate steady states of the U.S. and the three European economies with two different levels of the elasticity of substitution between various human capital levels, $\rho = 0.32$ and $\rho = 0.68$, the values considered in Gallipoli, Meghir, and Violante (2010). Results from the sensitivity analysis show that a lower (higher) elasticity of substitution of human capital is fully accommodated by lower (higher) productivity of the tertiary educational sector and lower (higher) psychological costs. In particular, tertiary attainment composition across skill groups, tertiary attainment in each skill group, intergenerational mobility, or credit constraints with respect to financing tertiary education, are very close to the benchmark steady state for each economy.

Dissecting the results. Previous discussion suggests that, in addition to the differences in educational policies, there are two key differences between the United States and the European countries: differences in the productivity of the tertiary sector, and the differences in the psychological costs of tertiary education. We consider an experiment where we ask what would happen, if the European countries had psychological costs κ and relative productivity θ as in the United States, but retained its own tax and educational policies.[14] Table 6 shows the results. There are two main effects. First, both changes tend to increase the educational premium: higher psychological costs κ increase it by depressing college attendance, while an increase in θ increases the educational premium directly for a given relative labor supply. As a result, the tertiary educational premium in the European countries skyrockets: for example in Germany, it increases from 1.398 to 1.826. In all three countries the tertiary educational premium increases above the tertiary educational premium in the United States. In case of college attainment, changes in κ and θ work in the opposite direction: higher κ decreases college attainment while higher θ increases it. Overall, however, the second effect dominates and the tertiary attainment

[14]We also considered what would happen if the European countries had U.S. earning profiles, but the effect is negligible, and is not reported.

Table 6: Experiment - U.S. Psycho Costs and U.S. θ

		Europe		
	U.S.	FRA	GER	U.K.
Education Premium	1.730	1.767	1.826	1.879
Tertiary Attainment	0.388	0.400	0.384	0.364
Tertiary Attainment Composition Across Skill Groups				
Low	0.064	0.039	0.041	0.043
Medium	0.221	0.205	0.143	0.141
High	0.715	0.756	0.816	0.817
Tertiary Attainment in Each Skill Group				
Low	0.071	0.045	0.045	0.045
Medium	0.259	0.247	0.165	0.154
High	0.867	0.948	0.979	0.926

Note: Psychological costs and θ are as in the U.S. Education premium and attainment is not matched.

increases to levels comparable to the United States: In France the tertiary attainment increases to 0.400, in Germany to 0.384, and in the United Kingdom to 0.364.

To summarize, if the European countries adopted U.S. psychological costs and tertiary productivity, they would have almost identical tertiary educational attainment, and even higher tertiary educational premium. They would also increase their steady state consumption, as well as output and capital stock, significantly above the corresponding U.S. values.[15] Why do they have a higher educational premium, consumption, output and capital stock? Table 6 shows that the European countries have a different skill composition at a tertiary level. In all three European countries almost all high skilled individuals attend college: In France, 94.8 percent , in Germany 97.9 percent, and in the United Kingdom 92.6 percent. All those fractions are significantly higher than in the United States, where the corresponding fraction is only 86.7 percent.

To understand the differences in educational decisions of various skills, we assess the importance of credit constraints. We define the percentage of credit constrained households as in Carneiro and Heckman (2002): It is the gap between the percentage enrollment in the highest income quartile for each ability level and the percentage enrolled

[15]One can show that, predictably, if Europe adopted only U.S. psychological costs, their tertiary educational attainment would drop significantly, while if they adopted only U.S. tertiary productivity, the educational attainment would significantly increase, with the tertiary premium being somewhere in between. Exact numbers are not shown for the sake of brevity.

Table 7: Fraction of Credit Constrained Households

		Europe		
	U.S.	FRA	GER	U.K.
Benchmark	0.041	0.108	0.108	0.059
Experiment	0.041	0.005	0.002	0.019
U.S. Subsidies	0.041	0.124	0.119	0.075
U.S. Income Tax	0.041	0.097	0.107	0.051
Flat Tax	0.032	0.098	0.124	0.073

Note: Fraction of credit constrained households is the gap between the percentage enrollment in the highest income quartile for each ability level and the percentage enrolled in the other income quartiles, see Carneiro and Heckman (2002).

in the other income quartiles. Table 7 shows that, in the U.S. economy, 4.1 percent of students' households are financially constrained, which is comparable to Carneiro and Heckman (2002), where 5.15% students' households are financially constrained. We find that a combination of U.S. educational technology and European educational subsidies virtually eliminates credit constrained households in the European countries. While in the benchmark allocation United Kingdom has 5.9 percent of credit constrained households and both France and Germany have 10.8 percent of credit constrained households, significantly more than United States, adopting U.S. educational technology decreases those fractions to only 0.2 percent in Germany, 0.5 percent in France, and 1.9 percent in the United Kingdom. High tertiary productivity is thus a driving force not only of high tertiary attainment, but also of relatively low importance of credit constraints.

7 Policy Reforms

We now consider a series of policy reforms, where European countries adopt U.S. policies, all countries adopt a flat tax, and all countries allow their tertiary education to be either fully private or fully public.

U.S. policies in Europe. In the first two reforms, reported in Table 8, European countries adopt U.S. educational costs and subsidies (first reform) and U.S. income tax (second reform).

If the European educational subsidies decrease to the U.S values reported in Table

Table 8: U.S. Policies in Europe

	Educational Policies				Income Tax			
	U.S.	FRA	GER	U.K.	U.S.	FRA	GER	U.K.
Education Premium	1.730	1.533	1.491	1.520	1.730	1.384	1.282	1.423
Tertiary Attainment	0.388	0.223	0.229	0.277	0.388	0.262	0.282	0.305
Tertiary Attainment Composition Across Skill Groups								
Low	0.064	0.071	0.069	0.057	0.064	0.084	0.187	0.062
Medium	0.221	0.067	0.065	0.054	0.221	0.057	0.053	0.049
High	0.715	0.862	0.866	0.889	0.715	0.859	0.760	0.888
Tertiary Attainment in Each Skill Group								
Low	0.071	0.045	0.045	0.045	0.071	0.063	0.151	0.055
Medium	0.259	0.045	0.045	0.045	0.259	0.045	0.045	0.045
High	0.867	0.600	0.619	0.766	0.867	0.698	0.666	0.839

Notes: Columns 1-4: European countries adopt U.S. educational costs and policies. Columns 5-8: European countries adopt U.S. income tax. Other parameters as in the benchmark economies in Table 5.

1, their tertiary attainment decreases as well: by 2 percentage points in France, by 2.7 percentage points in Germany, and 1.6 percentage points in the United Kingdom. The effects on educational attainment are thus small overall, representing only 13.8 percent (United Kingdom) to 20.5 percent (Germany) of the overall differences in tertiary educational attainment. The response in tertiary attainment is small mainly due to the general equilibrium effects, where relative wages respond to changes in relative labor supply.[16] Adoption of U.S. educational policies also increases the importance of credit constraints: there is now 12.4 percent of credit constrained households in France, 11.9 in Germany, and 7.5 percent in the United Kingdom, an increase of 1.1-1.6 percentage points (see Table 7). As a result, the fraction of high skilled individuals with college education decreases, by 4.7 percent (United Kingdom) to 8.3 percent (France). European countries thus produce a more heterogeneous skill mix at the tertiary level.

If European countries adopt U.S. income tax, their tertiary attainment increases by about the same amount: by 1.9 percentage points in France, 2.6 percentage points in Germany, and 1.2 percentage points in the United Kingdom. Less progressive income tax increases relative rates of return on education, although the general equilibrium

[16]We have also computed a partial equilibrium response to the adoption of U.S. educational policies, and the effects are drastically different: tertiary attainment decreases to 4.5-5.3 percent in the three European countries.

Table 9: A Flat Tax Reform

	U.S.	FRA	GER	U.K.
Education Premium	1.503	1.367	1.220	1.301
Tertiary Attainment	0.438	0.266	0.289	0.326
Tertiary Attainment Composition Across Skill Groups				
Low	0.280	0.103	0.265	0.190
Medium	0.099	0.056	0.052	0.046
High	0.621	0.841	0.683	0.763
Tertiary Attainment in Each Skill Group				
Low	0.348	0.079	0.221	0.180
Medium	0.131	0.045	0.045	0.046
High	0.856	0.694	0.615	0.772

Note: Flat tax on earnings, capital income taxed at country specific τ_k. Psychological cost of education as in the benchmark economies in Table 5.

effects again prevent the outcomes from being quantitatively more significant.[17]

Flat tax. In the next reform we consider a situation where all four countries replace their income tax by a flat tax. Table 9 reports the results. Flat tax increases tertiary attainment in all four countries. The most significant increase occurs in the United States where tertiary attainment increases by 5 percentage points. In Germany and United Kingdom the increase is a more modest 3.3 percentage points, while in France, tertiary attainment increases only by 2.3 percentage points. Given that the education technology does not change, tertiary educational premium decreases in all countries. At the same time, the composition of college educated individuals has a higher proportion of especially low skilled in all four countries and so leads to more mixed skill composition at tertiary level. Flat tax makes very low incomes much less attractive and, since low skilled individuals with secondary education face the lowest earnings, increases especially their incentives to increase their education.

[17] Adopting U.S. consumption tax marginally increases tertiary attainment, while adopting U.S. tax on capital has almost no effect on the tertiary attainment, and is not reported.

8 Efficiency of Educational Decisions

The educational decisions in our model are not socially optimal because of the borrowing constraint, and because of market incompleteness.[18] We do not attempt to define any notion of "second best" efficiency since any such candidate would be extremely hard to compute and would take us too far away from the main goal of the paper. Nevertheless, we find it useful to compare the schooling decisions with some measure of efficiency. To do so, we look at how well the schooling system allocates skills across educational levels relative to the first-best allocation of skills across educational levels.

In the steady state first-best allocation the social planner allocates a consumption to a household of age j $c_j(z) \in \mathbb{R}_+$ that depends only on the skill vector $z \in Z^3$, makes a schooling decision for an age 5 household, $s(z^s) \in \{0, 1\}$ that depends only on the skill level of the son $z^s \in Z$, and chooses capital stock for the next period. The social planner maximizes the expected lifetime utility of a dynasty, subject to the resource constraint.[19] Education decisions are made on the basis of comparative advantage. Denote $B_S(z^s)$ and $B_T(z^s)$ to be the expected present discounted value of the efficiency units of labor at the secondary and tertiary sector for a son with skill level z^s. We can show that the gains from a tertiary education are given by

$$\Delta(z^s) = w_T B_T(z^s) - w_S B_S(z^s) - \frac{\kappa(z^s)}{\nu} - x_T,$$

where ν is the (appropriately normalized) marginal utility of consumption, and $w_S = F_L L_{H_S}$ and $w_T = F_L L_{H_T}$ are marginal products of labor in the secondary and tertiary sector. The gains from tertiary education are thus equal to the "monetary" gains $w_T B_T(z^s) - w_S B_S(z^s)$ minus the psychological costs expressed in consumption goods $\kappa(z^s)/\nu$, minus the resource costs x^T. The social planner chooses tertiary schooling for sons with skill z^s if $\Delta(z^s) > 0$, is indifferent between tertiary and secondary schooling if $\Delta(z^s) = 0$, and prefers only secondary schooling if $\Delta(z^s) < 0$. General equilibrium considerations enter the costs and benefits of tertiary education in two ways: through the marginal products in the two sectors w_T and w_S, and through the marginal utility of consumption ν. Note also that it is by no means obvious that higher skilled individuals are more likely to be assigned to college than lower skilled individuals. The psychological costs are not monotone in skills, and the monetary gain may not be monotone either,

[18] There is also a small positive externality, since deceased households are replaced with new households with equilibrium composition of their human capital. Since the number of deceased households is small, we conjecture that this externality is not quantitatively significant.

[19] The details of the first-best problem are relatively standard, and are available upon request.

especially if higher skilled individuals have high earnings in the tertiary sector.

Table 10: Efficient Allocations

		Europe		
	U.S.	FRA	GER	U.K.
Education Premium	1.782	1.446	1.409	1.426
Tertiary Attainment	0.379	0.243	0.250	0.289
Tertiary Attainment in Each Skill Group				
Low	0.000	0.000	0.000	0.000
Medium	0.192	0.000	0.000	0.000
High	1.000	0.772	0.794	0.918
Misallocated Skills	0.090	0.066	0.061	0.065

Note: All parameters are as in the benchmark calibration. Misallocated skills measures a fraction of individuals with benchmark educational attainment different from efficient educational attainment.

The optimal education premium, tertiary attainment, and skill allocation are reported in Table 10. The efficient education premium rises from 1.730 to 1.782 in the U.S., decreases from 1.453 to 1.426 in the U.K., and stays about the same in Germany and France. Perhaps surprisingly, the efficient tertiary educational attainment is very close to the equilibrium attainment in all three countries (in fact, in France, it is almost identical). Thus, low educational attainment in the European countries is not necessary inefficient given the productivity of the educational sector ζ and other exogenous parameters. The last panel of Table 10 in fact shows that the allocation of skills is somewhat more efficient in the European countries. In each of the three European countries the social planner assigns tertiary schooling only to high skilled individuals, although some high skilled individuals only have secondary schooling. No middle or low skilled individual is assigned tertiary schooling. The equilibrium allocation of skills is very similar, with only a small fraction of low- and medium-skilled individuals attending college (see the last panel of Table 5). Overall, between 6.1 and 6.6 percent of individuals are misallocated in a sense that they end up with education level that the social planner would not assign to them. In the United States, the social planner assigns all high-skilled and 19.7 percent of medium-skilled individuals to college. In equilibrium, only 86.7 percent of high skilled individuals attend college, while 25.9 percent of medium skilled individuals and 7.1 percent of low skilled individuals attend college. The allocation of skills is thus more ”noisy” from the efficiency perspective and leads to too few high-skilled agents and too many low- and medium-skilled agents with tertiary schooling. Overall, 9 percent of individuals are misallocated, which is more than in any of the three European countries.

9 Intergenerational Mobility in Education

We measure intergenerational mobility in education first as a probability that children will go to college conditional on father having a college degree (persistence in education), and as a probability that children will go to college conditional on father having only a high school degree (upward mobility). Table 11 reports the results for the benchmark economy, for the experiment where European countries adopt U.S. psychological costs and U.S. productivity (see Table 6), and for our series of policy reforms (Tables 8 - 9). As shown in the first panel of the Table, persistence in education is about the same in all four economies, with approximately 50% of children of college educated fathers going again to college. Adopting a combination of US productivity in education θ and U.S. psychological costs, as in Table 6, decreases the persistence only slightly.

The upward mobility in education is, however, significantly lower in Europe, with only 16-20 percent of children with high school educated father going to college, compared with 31.7 percent in the United States. Moreover, unlike persistence in education, the upward mobility responds strongly to changes in the productivity of tertiary education and psychological costs. Adopting U.S. values increases upward mobility to values comparable to the United States, with France even exceeding it.

A flat tax reform also leads to relatively significant changes in the intergenerational mobility in education. Persistence in education does not change much in the United States, but increases in all three European countries - by 2.9 percentage points in France, by 5.5 percentage points in Germany, and by 4.5 percentage points in the United Kingdom. Upward mobility, on the other hand, increases only in the United States by 7.9 percentage points, but stays almost unchanged in all three European countries. Financing tertiary education entirely from public sources increases upward mobility significantly only in the United States (by 4.5 percentage points) while a fully private education lowers upward mobility in all countries by 2-3 percentage points.

We also compute the efficient intergenerational mobility in education for the first best allocations described in the previous Section, and report it on the last line in each of the two panels of Table 11. Since education decisions are determined only by a son's skill, the efficient mobility is driven purely by the intergenerational correlations in skills and by the efficient allocation of education across skills. The equilibrium persistence in education is, from the perspective of a first best allocation, too low in the United States,

Table 11: Intergenerational Mobility in Education

	U.S.	Europe		
		FRA	GER	U.K.
Persistence in Education				
Benchmark	0.490	0.485	0.500	0.498
Experiment	0.490	0.482	0.497	0.498
U.S. Subsidies	0.490	0.469	0.475	0.492
U.S. Income Tax	0.490	0.508	0.537	0.509
Flat Tax	0.486	0.514	0.555	0.543
Efficient	0.553	0.406	0.417	0.483
Upward Mobility in Education				
Benchmark	0.317	0.160	0.167	0.202
Experiment	0.317	0.341	0.307	0.281
U.S. Subsidies	0.317	0.147	0.151	0.189
U.S. Income Tax	0.317	0.169	0.175	0.209
Flat Tax	0.396	0.170	0.174	0.215
Efficient	0.276	0.170	0.175	0.202

Note: Persistence is the probability that children will go to college conditional on father going to college. Upward mobility is the probability that children with high school educated father will go to college. Experiment as in Table 6.

and too high in all three European countries, although in United Kingdom it is very close to the efficient level. On the other hand, United States have too high upward mobility, while the upward mobility in Europe is too low, with United Kingdom being again close to the efficient level.

10 Conclusions

This paper analyzes the effects of tertiary educational systems in the United States and Europe. We build a detailed model with heterogeneous agents and dynastic households who optimally accumulate human capital. In the United States, where government share in the economy is lower and tertiary schooling is predominantly funded from private resources, the tertiary education earnings premia are much higher than in Europe. There the government consumption represents a much higher share of GDP, tertiary education is paid for by the government, and the tertiary education premium is low.

The main role in explaining the differences belongs to a lower productivity of the tertiary sector. We take the productivity as given, and leave the question of why the productivity takes the observed pattern for future research. We find that European educational policies lead to a higher tertiary attainment, but the effect is significantly weaker than the effect of lower productivity. At the same time, higher educational subsidies lead to a more efficient composition of skill in higher education.

We find that the allocation of talent is quite close to the first-best. Nevertheless, in our future research we plan to investigate to what extent a system of merit based subsidies and debt-financed schooling support that would not crowd out too many productive resources from the economy would increase the efficiency further.

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A Appendix: Stationary Recursive Competitive Equilibrium

Definition 1. *Given schooling subsidies d, tax policies (SS, t, τ_k, τ_c), cost of schooling κ, and government consumption G, a stationary recursive competitive equilibrium is a set of value functions $\{V_j(\cdot)\}_{j=1}^T$, household policy functions $\{c_j(\cdot), a'_j(\cdot), s_j(\cdot)\}_{j=1}^T$, factor prices (w_S, w_T, r), accidental bequest transfers ξ, measures $\{\lambda_j\}_{j=1}^T$ such that:*

1. *given government policies and prices, household policy functions solve problems (2), (4) and (7);*
2. *the prices (w_S, w_T, r) are given by (10) and (11);*
3. *aggregate levels of capital K, human capital $H_i, i \in \{S, T\}$, consumption C, school enrollment $S(\bar{h}_i, \bar{z}_i)$, schooling subsidies D, schooling costs X, social security benefits SS, and tax revenues T are*

$$
\begin{aligned}
K &= \sum_{j,a,h,z} a\,\lambda_j(a,h,z)\,(1+n)^{1-j},\\
H_i &= \sum_{j,a,h,z} [\phi_g(z^g)\varepsilon_{j+2T}(\bar{h}_i, z^g)1_{h^g=\bar{h}_i} + \phi_f(z^f)\varepsilon_{j+T}(\bar{h}_i, z^f)1_{h^f=\bar{h}_i}\\
&\qquad + \phi_s(z^s)\varepsilon_j(\bar{h}_i, z^s)1_{h^s=\bar{h}_i}]\lambda_j(a,h,z)\,(1+n)^{1-j},\\
C &= \sum_{j,a,h,z} \phi(z)c_j(a,h,z)\,\lambda_j(a,h,z)\,(1+n)^{1-j},\\
S(\bar{h}_S, z^s) &= \sum_{a,h,z} \phi_s(z^s)\,\lambda_4(a,h,z)\,(1+n)^{-3},\\
S(\bar{h}_T, z^s) &= \sum_{a,h,z^s} \phi_s(z^s)\,s_5(a,h,z)\,\lambda_5(a,h,z)\,(1+n)^{-4}\\
D &= \sum_{z^s} d(z^s)S(\bar{h}_T, z^s),\\
X &= \sum_{\bar{h}_i, z^s} x(\bar{h}_i)S(\bar{h}_i, z^s),\\
SS &= \sum_{j=j_R}^{3T}\sum_{a,h,z} \phi_g(z^g)SS_j(h^g, z^g)\,\lambda_j(a,h,z)\,(1+n)^{1-j},\\
T &= \sum_{j,a,h,z} t_j(h,z,s_j(a,h,z))\,\lambda_j(a,h,z)\,(1+n)^{1-j};
\end{aligned}
$$

4. *accidental bequests are*

$$
(1+n)\xi = (1+r)\sum_{j,a,h,z} \phi_j(z)(1-\psi_j(z',z))\,a_j(a,h,z)\,\lambda_j(a,h,z)\,(1+n)^{1-j};
$$

5. *the measures* $\{\lambda_j\}_{j=1}^{T}$ *are time invariant;*

6. *the government's budget is balanced*

$$G + D + SS = \tau_k r K + \tau_c C + T;$$

7. *and the aggregate feasibility constraint holds,*

$$C + (1+n)(1+\gamma)K + G + X = F(K, L) + (1-\delta)K.$$

B Appendix: Data Sources

1. *Publicly Financed Costs (Table 1)*: The data are taken from OECD (2006), Tables B3.2a,b, B5.2, B5.3, and are for year 2004.

2. *Educational Attainment (Table 1)*: The data are taken from OECD (2006), Tables A1.2a, A1.3a, for year 2004.

3. *Tertiary Earnings Premium (Table 1)*: The data are from OECD (2006), Table A9.1a.

4. *Educational Expenditures (Table 1)*: Total Expenditures per student, both public and private, are from OECD (2006), Table B1.1.a. To express them as a fraction of GDP per capita, they are divided by GDP per capita from OECD (2006), Table X2.2. The data are for year 2004.

5. *Public Expenditures on Education, as a fraction of GDP (Table 1)*: The data are from OECD (2006), Table B4.1 (year 2003)

6. *Earnings Data for USA, Germany and Great Britain (Figure 2)*: As mentioned in the text, the data we use are PSID data for the United States, BHPS data for United Kingdom, and GSOEP data for Germany. Our sample selection departs from the one made in Heathcote et al. (2010), Blundell and Etheridge (2010) and Fuchs-Schuendeln et al. (2010) only in two important ways: We look at individuals between 18 and 65 years rather than between 25 and 60 years. In addition, in case of United States, we restrict attention to date between 1983 and 2005 to match the time span of the GSOEP panel (BHPS panel consists of observations for only years 1991-2005).

   Labor earnings are defined as labor earnings of the head. Labor earnings are deflated by the Consumer Price Index. A person is the PSID sample is assigned a college status if he/she completed 16 grades or more. A person in the GSOEP sample is assigned a college status if he/she reports that he/she has completed either university or technical college. A person in the BHPS panel is assigned a college status if he/she has a honours degree or equivalent. Overall, 31.80% of respondents in PSID, 19.69% of respondents in GSOEP and 48.5% of respondents in BHPS have obtained college education or more. Those fractions differ from the nationwide educational attainment data, mainly because the composition of the samples does not replicate the composition of total population.

In all three datasets we exclude observations if i) heads of household are younger than 18 or older than 65, ii) there is no information on age for either head or spouse, iii) either head or spouse have positive labor income but zero annual hours, iv) either the head or spouse had wages that are less than one half of the minimum wage prevailing in that year in case of United States and less than 3 Euros in case of Germany, and v) when the head of household works less than 520 and more than 5840 hours per year. Finally, vi) All individuals who belong to the SEO subsample of PSID or the high income subsample of GSOEP, and all individuals who are not heads of household are excluded. Top-coded earnings are replaced by forecasted mean earnings assuming that the distribution is Pareto (see Heathcote et al. (2010) for details). After these adjustments, the final PSID sample contains 51766 individual-year observations, the final GSOEP sample contains 107031 individual-year observations and the final BHPS panel contains 35018 individual-year observations.

7. *NLSY Data (Tables 2 and 3)*: We use data from 1979 to 2008. The initial sample contains 12687 people. We drop individual observations if i) their earnings are not reported or are negative, ii) hours worked are less than 520 and more than 5840 hours per year, iii) individuals report wages less than 1*ormorethan*400 in 1992 dollars, iv) individuals are classified as unemployed, out of labor force and in the military, v) individuals who change their education during their working life, vi) individuals who report invalid AFQT score, and vii) people who are in the cross-sectional (representative) sample. The sample selection is almost identical to the one in Gallipoli et al. (2010). It leaves us with 4142 individuals and 54424 individual-year observations. From those individuals, 583 has less than high school, 2654 are high school graduates, and 905 are college graduates.

8. *Labor, Consumption and Capital Taxes (Table B.1)*: The labor wedge is computed by summing the federal and local income taxes, social security contributions of both employee and employer, subtracting family benefits, and dividing by total labor earnings. We compute the tax wedge for a married couple with one earner and two children. See OECD (2008) section I for a detailed construction of the tax wedge. Capital and consumption tax rates are taken from Uhlig and Trabandt (2009), who extend the methodology of Mendoza et al. (1994) for recent years. We average the values between 2000 and 2006. The labor wedges (for selected income levels) and the capital and consumption taxes are shown in Table B.1.

9. *Social Security Replacement Rates (Table B.1)*: Source: *Pensions at a Glance 2011: Retirement-Income Systems in OECD Countries*, OECD 2011

Table B.1: Taxes and Social Security

		Europe		
	U.S.	France	Germany	U.K.
Average Labor Wedge				
Multiple of average earnings:				
0.5	-0.085	0.222	0.200	-0.100
0.75	0.072	0.401	0.300	0.185
1 (Average)	0.177	0.421	0.364	0.269
1.5	0.235	0.443	0.395	0.325
2	0.262	0.461	0.383	0.370
Capital Tax Rate				
	0.316	0.319	0.245	0.374
Consumption Tax Rate				
	0.074	0.240	0.150	0.174
Social Security Replacement Rates				
Multiple of average earnings:				
0.5	0.517	0.559	0.420	0.538
0.75	0.435	0.491	0.420	0.392
1 (Average)	0.394	0.491	0.420	0.319
1.5	0.353	0.413	0.420	0.226
2	0.297	0.371	0.323	0.169
Total Government Expenditures (% of GDP)				
	0.215	0.328	0.240	0.258

Note: Social security replacement rates as percentage of individual gross earnings, for brackets denoting multiples of average gross earnings.

(www.oecd.org/els/social/pensions/PAG). Retirement age is set at 65. In order to assign compatible social security benefits across countries, we use the reported replacement ratios as a function of gross individual earnings relative to the average gross individual earnings in each country. These replacement rates are reported in the second part of table B.1. Data for all countries are for year 2008.

10. *Government Expenditures (Table B.1)*: Total Public Expenditures are from OECD, National Accounts.

C Appendix: Sensitivity Analysis

In this Appendix we simulate steady states of the U.S. and the three European economies with two different levels of the elasticity of substitution between various human capital levels. In particular, we simulate steady states with $\rho = 0.32$ and $\rho = 0.68$, that is values considered in Gallipoli, Meghir, and Violante (2010). As in Table 5, tertiary attainment and tertiary earnings premium are matched to country specific data, while the skill composition at tertiary level is only matched for the U.S. economy.

C.1 Elasticity of Substitution of Human Capital $\rho = 0.32$

Table C.1 shows that when the elasticity of substitution between human capital levels is set to $\rho = 0.32$, the relative productivity of the tertiary educational sector $\zeta = \theta/(1-\theta)$ is independent falls to $\zeta = 1.155$ in the United States, and to 0.595 in France, to 0.592 in Germany, and to 0.695 in the United Kingdom. The tertiary educational sector's productivity is now only one half in France and Germany, and 60% in the United Kingdom.

With lower elasticity of substitution, the psychological costs related to tertiary education have to fall by 14% in the United States. In the European countries, the psychological costs decrease as well in order to match the tertiary attainment. As in the benchmark calibration, the distribution of psychological costs across skill levels in the United States is calibrated to match the observed distribution of skill levels at college in Table 2. The costs remain non monotone across skills. The resulting allocation of college educated individuals is robust to changes in ρ. In particular, both tertiary attainment composition across skill groups and tertiary attainment in each skill group are very close to the benchmark, with the exception of Germany where they fall by 3-4 percentage points.

Other results in Table C.1 are very close to the benchmark results, including those for mobility and financial constraints related to tertiary education. These results suggest that a lower elasticity of substitution of human capital is fully accommodated by lower productivity of the tertiary educational sector and lower psychological costs.

Table C.1: Sensitivity Analysis: Allocations and Prices with $\rho = 0.32$

	U.S.	Europe FRA	Europe GER	Europe U.K.
Capital	0.656	0.713	0.787	0.623
Output	0.207	0.231	0.237	0.212
Consumption	0.141	0.152	0.172	0.147
Tax Exemption	-0.154	0.212	0.195	0.110
θ	0.536	0.373	0.372	0.410
Education Premium	**1.731**	**1.446**	**1.406**	**1.458**
Attainment	**0.389**	**0.244**	**0.254**	**0.290**
Psychological Cost of Tertiary Education by Skill				
Low	2.970	-1.166	-1.570	-2.596
Medium	3.793	-0.343	-0.748	-1.773
High	2.888	-1.248	-1.652	-2.678
Tertiary Attainment Composition Across Skill Groups				
Low	**0.070**	0.064	0.084	0.056
Medium	**0.214**	0.061	0.061	0.052
High	**0.716**	0.874	0.855	0.893
Tertiary Attainment in Each Skill Group				
Low	0.078	0.045	0.060	0.047
Medium	0.251	0.045	0.045	0.045
High	0.870	0.664	0.658	0.804
Intergenerational Mobility in Education				
Persistence	0.469	0.499	0.502	0.505
Upward Mobility	0.332	0.156	0.159	0.197
Credit Constrained Agents	0.039	0.108	0.110	0.062

Note: Each country has specific psycho costs based on level shift from U.S. psycho costs to match country total tertiary attainment. Country specific θ to match education premium. Attainment composition across skill groups is matched only in the U.S. economy. Outcomes in bold are matched to data in calibration. $\rho = 0.32$. All other parameters are the same as in the benchmark economy.

C.2 Elasticity of Substitution of Human Capital $\rho = 0.68$

In Table C.2, the elasticity of substitution between human capital levels is set to $\rho = 0.32$. The relative productivity of the tertiary educational sector rises to $\zeta = 1.37$ in the United States, and more fore European economies: it is more than two-thirds in France and Germany, and above 72% in the United Kingdom.

With higher elasticity of substitution, the psychological costs related to tertiary education increase by 16% in the United States. Similarly, these costs also increase in the other countries. The non monotone psychological costs of tertiary education again preserve similar tertiary attainment composition across skill groups while they decrease tertiary attainment in each skill group in Europe by around 2 percentage points.

The results in Table C.2 show that a higher elasticity of substitution of human capital leads to higher productivity of tertiary educational sector and higher psychological costs and otherwise similar steady state allocations to the benchmark economies.

Table C.2: Sensitivity Analysis: Allocations and Prices with $\rho = 0.68$

		Europe		
	U.S.	FRA	GER	U.K.
Capital	0.650	0.674	0.740	0.589
Output	0.207	0.218	0.224	0.201
Consumption	0.109	0.097	0.115	0.104
Tax Exemption	-0.176	0.057	0.058	0.020
θ	0.578	0.472	0.469	0.497
Education Premium	**1.731**	**1.449**	**1.406**	**1.453**
Tertiary Attainment	**0.391**	**0.243**	**0.254**	**0.290**
Psychological Cost of Tertiary Education by Skill				
Low	3.883	-0.892	-1.895	-3.088
Medium	5.082	0.307	-0.696	-1.889
High	3.832	-0.943	-1.946	-3.138
Tertiary Attainment Composition Across Skill Groups				
Low	**0.066**	0.069	0.069	0.068
Medium	**0.216**	0.063	0.061	0.052
High	**0.718**	0.868	0.871	0.880
Tertiary Attainment in Each Skill Group				
Low	0.074	0.047	0.049	0.057
Medium	0.256	0.045	0.045	0.046
High	0.878	0.640	0.672	0.791
Intergenerational Mobility in Education				
Persistence	0.453	0.485	0.499	0.501
Upward Mobility	0.347	0.154	0.159	0.198
Credit Constrained Agents	0.019	0.116	0.105	0.066

Note: Each country has specific psycho costs based on level shift from U.S. psycho costs to match country total tertiary attainment. Country specific θ to match education premium. Attainment composition across skill groups is matched only in the U.S. economy. Outcomes in bold are matched to data in calibration. $\rho = 0.68$. All other parameters are the same as in the benchmark economy.