# LOBBYING FOR EDUCATION IN A TWO-SECTOR MODEL

DEBORA DI GIOACCHINO, PAOLA PROFETA

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Debora Di Gioacchino
Sapienza Università, Roma, Italy

Paola Profeta
Università Bocconi, Milano, Italy

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*Debora Di Gioacchino, Sapienza Università di Roma, Via del Castro Laurenziano 9, 00161 Roma, Italy, debora.digioacchino@uniroma1.it; Paola Profeta, Università Bocconi, Via Roentgen 1, 20136 Milan, Italy, paola.profeta@unibocconi.it. We thank Maurizio Franzini, Vincenzo Galasso, Francesco Vona and Brunero Liseo for useful comments. We thank Elena Pisano for excellent research assistance.

**Abstract**

In this paper, firms specialized in two different sectors lobby to induce the government to subsidize the type of education complementary to their production. Lobbying is endogenous. We show that, if lobbying is not costly, both sectors will lobby in equilibrium and the education policy will induce the same skill composition that would be chosen by the social planner. However, if lobbying is costly and if there is sufficient asymmetry between the sectors, only one sector finds it profitable to offer monetary contribution and direct resources toward the type of education required by its production. Which sector will engage in lobbying depends on relative size, productivity and price in the two sectors.

JEL Classification: I2, D72.

# 1 Introduction

Modern economies devote a relevant share of their resources to education. However, even OECD countries differ not only in the share of GDP devoted to education, but also in the composition of education expenditures, in the graduation rate and in the distribution of graduates by level of education (primary/secondary vs tertiary), by program orientation (vocational vs general) and by field of education (cfr. tables 1 and 2). In countries such as the United States, United Kingdom and Canada, the education system is mainly oriented towards general rather than vocational programmes. Differently, Germany, Finland, Italy, and many others, have a relevant share of students enrolled in vocational programmes. As for the share of graduates by field of education, countries such as Korea, Finland and Sweden have a high share of graduates in engineering, while the United States, Luxemburg, Australia and New Zealand have a high share of students graduating in business.[1]

In this paper, we argue that differences in the composition of human capital are related to the production structure of the economy and we emphasize the potential key role of firms' political pressure activity. Skills are required by firms according to their needs and are acquired through the education system, whose outcome is a composition of human capital by level, field and program orientation. In a rapidly changing economy there is high demand for workers equipped with general skills, which are more mobile and can easily be adapted in new sectors. Analogously, the distribution by field of education should reflect the sectoral composition of the economy. Economies endowed with a higher share of human resources in science and technology are in a better position to innovate and expand production in high-tech sectors. On the other hand, if a relevant share of firms is specialized in high-tech production, demand for graduates in science and engineering

[1] Notice also that in Sweden 17% of students in 2008 graduated in engineering, manufacturing and construction; among them, 78% graduated in engineering. Analogously, in the United States, 40% of students graduated in social science, business and law; of them, 54% graduated in business. Even more striking are the differences among the shares of graduates by field of education relative to total population. In the United States, of the relatively low number of graduates for 1000 inhabitants (7.7) 3 graduated in social science business and law (SSBL) and 0.5 in engineering, manufacturing and construction (EMC). In Korea instead, of the 8.2 graduates for 1000 inhabitants, 1.9 graduated in SSBL and 1.9 in EMC.

is correspondingly high. Thus, the direction of causality is difficult to identify and the relationship is probably not one-way.

Table 3 reports, for the year 2006, the sectoral composition of production for 30 OECD countries. Countries such as Korea, Finland and to a certain extent also Ireland and Japan, have a high share of production in manufacturing, focused on high and medium-high tech, and a relatively lower share of value added in services. On the other hand, United States, United Kingdom and France have high share of production in services, mainly in finance insurance and business services.

As shown in figures 1 and 2, there appears to be a positive correlation between countries productive specialization and the composition of graduates by field of study. Figure 1 plots the shares of graduates in science and engineering in association with the share of value added in high-tech sectors. Figure 2 plots the share of graduates in social science, business and law in 2008 in association with the share of value added in finance, insurance and business services. However, the two diagrams, and the value of R-squared, also indicate that a relevant fraction of the variance remains unexplained.[2] This suggests that something else, beside an economy's sectoral composition, is needed to account for differences in the composition of human capital.

In this paper, we ask whether the missing ingredient may be related to politics and to political economy aspects. We start from the observation that firms have vested interests in education: private companies finance universities, in some cases to a large extent, they choose the field of study and the institution that they want to support and through these

[2]Korea, Finland and Germany have a higher share of SE graduates and a lower share of SS graduates, than required by their productive specialization. Differently, US and Iceland, as well as Hungary and Poland, have a higher share of SS graduates and a lower share of SE graduates than required by their sectoral composition.

Thus, figure 1 and 2 seem to suggest that there is excess supply of those skills which are used in the sectors with a higher share of value added. In fact, if we take the regression lines in figure 1 and 2 as representing an equilibrium between the labour force skill composition and the economy's sectoral composition, then the distance between a country's position and the regression line measures the excess supply, or scarcity, of the skill considered.

contributions they promote higher education in specific fields. At extreme cases, private firms or a group of them owns or control a private university. This fundraising activity has an old tradition and is well advanced in US universities, but in recent years it has started to develop also in top European universities. According to OECD, in 2007 private entities other than households spent in total tertiary education more than 1% of GDP in US and around 0.142% of GDP in UK. These expenditure are increasing: in 1999 they amounted to 0.57% of GDP in US and 0.12% in UK. Other countries where private entities spent a high amount of GDP in tertiary education are (2007, always as percentage of GDP) Korea (around 0.8%), Canada (0.6%) Australia (0.26% ). European countries stay behind these levels, but on an increasing or stable path: 0.18% of GDP is spent in the Netherlands, 0.16% in Sweden, 0.12% in Austria and 0.069% in France.

Firms interests in the outcome of education, i.e., in the production of skills, is also well documented in public speeches and debate. As argued by Bill Gates, for instance, education and in particular innovation is a crucial ingredient for success: "*Education isn't only a civil-rights issue but also an equity issue and an economic issue. It's so primary. In inner-city, low-income communities of color, there's such a high correlation in terms of educational quality and success. I bring a bias to this, I believe in innovation and that the way you get innovation is you fund research and you learn the basic facts*" (Bill Gates, Microsoft). More specifically, business leaders have to invest in the education necessary to create the needed jobs: "*Our recovery is dependent on hard-working small business owners across America who will create the jobs that America needs. I'm proud to be a part of this innovative program which provides greater access to know-how and capital: two ingredients critical to success.*" (Warren Buffett, Goldman Sachs). Even more importantly, firms are interested in specific fields of studies that relate to the current job opportunities: "*My first real involvement requiring a lot of my time was in approaching the New York City Board of Education to start a dialogue about a partnership between the public and private sectors in teaching subjects that would relate to actual job opportunities of the 21st century, not those of the 19th century as were being taught. That is when we came up with the idea of starting an academy of finance with the agreement of the chancellor and the board of education*" (Sanford Weill, Citigroup). US industry and academia agree

that a key recommendation for competitiveness is "*to expand the innovation talent pool in the United States by increasing the number of degrees awarded to students in math, science and engineering*".[3] Investments in research in computing and software is for instance urged by Microsoft: "*Only a few companies in the world are still funding basic research in computing and software"*, (Craig Mundie, Microsoft, at a recent meeting in Washington of top executives from more than 50 american corporations and universities, where participants complained that they cannot find qualified technology experts, and they expressed concern that the pool of researchers is becoming dangerously low as half of the country's scientists and engineers will retire in the next 10 to 12 years).

In Europe, where the lack of STEM (science, technology, engineering and mathematics) skills is recognized as one of the main obstacles to economic growth, companies have taken actions in order to increase the supply of STEM-skilled workers (Business Europe, 2011). Their role and involvment in this goal is crucial, including investing in education[4], in learning of teachers, in providing role models and raising awarness. At higher levels, cooperation between education providers and business is recognized as vital not only to increase the interest for STEM but also for the relevance of the studies. Companies also communicate to universities their future skills needs. In Germany for instance one out of three members of a university board comes from the business world. This activity is costly, both in terms of time and money. However, it also has a clear public value: consequences of the STEM shortages are not only detrimental for companies, but for the economic growth of the country.

Thus, as firms have an interest at stake on education, they may try to influence the government's policy on the issue. To give an example, in times of shortages of the needed STEM-skills, business considers STEM education of high quality and relevance to be a priority for public spending in European countries. In the UK for instance, 52% of

[3] http://www.eweek.com/c/a/IT-Management/Executives-Lobby-for-Increased-RD/

[4] In France, six companies (Areva, EADS, France-Télécom, Schlumberger, SNCF and Technip) are involved in the C.Genial project created in order to raise the attractiveness of scientific studies. In Germany companies involved in the initiative called "MINT create future!" aim at increasing the public awareness of the importance of STEM skills.

businesses call on the government to protect funding for STEM at university level.

Generally speaking, lobbying is any activity by special interests aiming at influencing public policy. These activities, which may include providing relevant information as well as payments and donations, require time and money. Since Grossman and Helpman's (1994) seminal paper, lobbying has been formalised as special interest groups offering (monetary) contributions to politicians.[5]

In this paper, we analyze the political economy of education in a setting in which firms specialized in (two) different sectors try to induce the government to finance the type of education which is complementary to their production. In our model, there is a continuum of firms specialized in one of the two sectors and a continuum of workers who live for two periods. In each sector, firms use as production-input labour of a given skill-type. The policy-maker decides the skill composition of new-workers, which will determine the supply of skills in the second period. Education is financed through a lump-sum tax on firms' profit. Thus, given the available resources, the policymaker can only choose the skill composition, but not the level of education. Firms may lobby the government to influence its education policy so as to obtain a favorable skill composition of the labour force. Following Bernheim and Winston's (1986) common agency approach, firstly applied in economics by Grossman and Helpman (1994), we assume that firms can offer monetary contributions to the policy-maker conditional on the structure of education chosen. Moreover, following a more recent strand of the literature (Baldwin and Robert-Nicoud, 2007), we allow for endogenous lobbying. We are able to show that, if there are no costs of lobbying, then both sectors will lobby in equilibrium. In this political equilibrium the policy-maker chooses the same skill composition that would be chosen by the social planner. However, if lobbying is costly, as it is more realistic to assume, it may be that only one sector will find it profitable to exert lobbying activity. This is the sector with a higher relative weight, measured by the relative size, productivity and price. Thus, the lobbying activity may contribute to explain differences in educational systems across economies *with similar production composition.*

[5] Monetary contributions are a metaphor for any utility transfer from lobbies to politicians; that is any action which is costly to the lobby and beneficial to the politician.

The rest of the paper is organized as follows: next section reviews the related literature; section 3 presents the model and section 4 derives the political equilibrium with endogenous lobbying; section 5 concludes. All proofs are in the appendix.

## 2 Related literature

Our paper brings together different strands of the literature. It contributes to the political economy of education by investigating the possibility that education policy responds to the interest of firms exerting pressure on the policy-makers in order to obtain their favorite human-capital composition. The political economy approach has mainly focused on the redistributive role of education and on income distribution as the main determinant of educational policy (see Di Gioacchino and Sabani, 2009). In this paper, we abstract away from education's redistributive role and focus on its effect on the "production" of skills. Thus, the conflict of interest is not among income groups but between firms active in different sectors and interested in the supply of different skills. Our results point to the possibility of multiple equilibria with different mix of education and production.

The focus on the complementarity between education and the structure of production closely relates our paper to the recent literature on the "varieties of capitalism" (Hall and Soskice, 2001, Iversen, 2005) which emphasizes how workers' investment in skills, firms' international product market strategies, social protection and electoral politics reinforce each other to determine a "welfare production regime".[6] So, the relative abundance of certain skills constitute a comparative advantage for firms that use those skills. Therefore, firms, interested in specific skills will support education policies that ensure an adequate return for workers who invest in those skills and social policies that protect this investment. Along this lines, we explicitly model firms' active political role in shaping education policy through lobbying.

[6] See also Bénabou (2003), where the distribution of human capital, technological choice and redistributive institutions are simultaneously determined. Unlike ours, in his paper firms do not try to influence the distribution of human capital, which they take as given when choosing (the degree of flexibility in) their technology.

The idea that the educational structure is functional to the interest of firms (the capitalist class) can be found in Bowles (1978) and more recently in Galor and Moav (2006).[7] They argue that due to capital-skill complementarities, the accumulation of physical capital in the process of industrialization increased the importance of human capital and generated incentives for capitalists to support the provision of universal education. Our paper is tightly related to Galor and Moav (2006); as in their work, we view the educational system as the upshot of political and economic conflicts; however, we assume heterogeneity in the human capital used in different industries and thus allow for a conflict of interests among capitalists. Moreover, differently from previous contributions, we use lobbying to characterize the political process and we develop an endogenous lobbying model.

Our paper is also related to the recent literature on the interplay among human capital, technology, the structure of production and economic growth.[8] Since Nelson and Phelps' 1966 seminal paper, it has been recognized that a more educated labour force would adopt new technologies faster and, at the same time, the demand for skill would increase as new technologies are introduced (Acemoglu, 2002). This literature points out the possibility of multiple equilibria. One equilibrium is characterized by high levels of human capital, faster adoption of new technologies and high share of production in high-tech industries, while the other equilibrium depicts low levels of human capital, higher distance from the "technological frontier" and production specialized in traditional sectors. A strand of this literature has recognized the importance of distinguishing between different types of human capital. Vandenbussche et al. (2006) have shown the growth-enhancing effects of tertiary education, especially for economies close to the technological frontier. Murphy et al. (1991) have demonstrated that the allocation of talent has significant effects on the growth rate of an economy. The reason is that economies which reward entrepreneurship more than rent seeking activities attract talented people in the more productive sectors. Using data

[7] The role of social conflict in shaping the educational system has also been stressed by Bertocchi and Spagat (2004). Other studies have identified different sources of conflict between social classes, related for instance to social mobility (see Bernasconi and Profeta, 2011).

[8] On the macroeconomic side and the evolution of wage inequality, see also the literature on the role of the skilled-biased technological change as responsible of the increase in the US skill premium (Krusell et al., 1999).

on college enrolment in law as a measure of talent allocated to rent seeking activities, and on college enrolment in engineer as a measure of talent allocated to entrepreneurship, their empirical evidence confirms that countries with high proportion of engineers grow faster than countries with high proportion of lawyers. More recently, in a model of growth with households' education choice and costly technological adoption by firms, Krueger and Kumar (2004a, 2004b) have argued that an economy whose policies favour skill-specific, vocational education, will growth slower than an economy whose policies favour general education. In this paper we set aside technological progress, thus limiting firms' economic role, to emphasize firms' political role in directing education spending.

# 3 The model

The economy is populated by firms and individuals. Firms are a continuum of measure one and live indefinitely. Each firm is owned by a single entrepreneur. Individuals are a continuum of measure one and live for two periods. In the first period, they receive skill-specific education; in the second period they inelastically supply labour and are hired by firms in the sector that use as input the skill they have acquired. Firms may try to influence the government's education policy by exerting lobbying activity. We follow the approach to lobbying pioneered by Grossman and Helpman (1994) and assume that firms may get organised and offer political contributions to the policy-maker conditional on the skill composition chosen.

We restrict our attention to a two-sector and two-education type economy. Let $\gamma$ be the fraction of firms in the first sector ($f$) and using workers with the first type of education ($F$) and $1-\gamma$ be the complementary set of firms, producing in the second sector ($s$) and using the second type of human capital ($S$).[9] We indicate by $\delta$ the share of workers with skill type $F$ and by $1-\delta$ the complementary share of workers with skill type $S$.[10] All

[9] We will suggest some interpretation of the results for two sectors with high and low productivity, but the model itself is more general. The two sectors may differ for the goods produced (e.g. service vs manufacture) or for the use of general vs specific skills or they may differ along other dimensions.

[10] The model is quite general. The two types of education may represent different fields (e.g. business vs engineering) as well as different programme orientation (general vs vocational) etc.

firms in the same sector are identical.

The model has four stages. In the first stage, firms decide whether to pay a fixed cost to get organised in lobby. Forming a lobby is a way of exerting political influence on the government's decision-making. In the second stage, lobbies provide the government with contribution schedules that truthfully reveal their preferences over education. In the third stage, knowing the contribution function, the government chooses the education mix, which determines the skill composition of the labour force. Finally, in the last stage, firms take production decisions, wages are paid and profits are realised. To find the (subgame perfect) equilibrium, the model is solved backwards.

Notice that in our setting individuals are completely passive; they are not politically organised, nor they decide which type of education to acquire.[11] We assume that the education mix is entirely determined by the government. This is meant to highlight the potential role of government intervention in influencing individuals' choice. In practice, this influence, which the government shares with the education providers (universities, colleges, local authorities etc.), might come through subsidies and/or through the decision on which formation/program to offer.

### 3.1 Production

Firms' unique production input is labour. Recalling the definition of $\delta$ and $\gamma$, each representative firm in sector $f$ employs $\frac{\delta}{\gamma}$ workers and each representative firm in sector $s$ employs$\frac{1-\delta}{1-\gamma}$ workers. Let $A_f, A_s$ denote the level of labour-augmenting technology in sector $f$ and $s$, respectively so that if workers with the first type of education are more productive than workers with the second one, we expect $A_f$ to be larger than $A_s$.

Thus, output for each representative firm in the two sectors is, respectively:

$$y_f = A_f \left(\frac{\delta}{\gamma}\right)^{\alpha} \tag{1}$$

$$y_s = A_s \left(\frac{1-\delta}{1-\gamma}\right)^{\alpha} \tag{2}$$

[11] Alternatively, and without altering the results, we may consider that government finances education through subsidies targeted to the acquisition of different education types and, given government subsidies, each individual chooses which education type to acquire, conditional on his talent.

where $\alpha \in (\frac{1}{2}, 1)$.

Total output in the two sectors and in the whole economy are, therefore:

$$Y_f = \gamma y_f = \gamma^{1-\alpha} A_f \delta^{\alpha}$$

$$Y_s = (1-\gamma) y_s = (1-\gamma)^{1-\alpha} A_s (1-\delta)^{\alpha}$$

$$Y = \gamma^{1-\alpha} p_f A_f \delta^{\alpha} + (1-\gamma)^{1-\alpha} p_s A_s (1-\delta)^{\alpha} \tag{3}$$

where total output price has been normalized to one and $p_f$ and $p_s$ denote (relative) prices in the two sectors**.**

Labour market is competitive and workers are paid their marginal productivity; thus wages for sector $f$ and $s$ are, respectively:[12]

$$w_f = \alpha \gamma^{1-\alpha} A_f p_f \delta^{\alpha-1} \tag{4}$$

and

$$w_s = \alpha (1-\gamma)^{1-\alpha} A_s p_s (1-\delta)^{\alpha-1} \tag{5}$$

Notice that a worker's wage depends positively on the size, productivity and price of the sectors he is employed in and it is inversely related to the share of the population which holds his same skill.

Each representative firm in the two sectors earns profits given by

$$\pi_f = (1-\alpha) A_f p_f \left(\frac{\delta}{\gamma}\right)^{\alpha} \tag{6}$$

and

$$\pi_s = (1-\alpha) A_s p_s \left(\frac{1-\delta}{1-\gamma}\right)^{\alpha} \tag{7}$$

Using Eq. (4) and Eq (5) , we can write the relative wage as follows:

$$\frac{w_s}{w_f} = \left(\frac{1-\gamma}{\gamma}\right)^{1-\alpha} \frac{A_s}{A_f} \frac{p_s}{p_f} \left(\frac{\delta}{1-\delta}\right)^{1-\alpha} \tag{8}$$

where $\frac{1-\gamma}{\gamma}$ measures the relative size of the two sectors, $\frac{\delta}{1-\delta}$ measures the relative scarcity of the two types of workers, $\frac{A_s}{A_f}$ measures the relative productivity and $\frac{p_s}{p_f}$ the relative price in the two sectors.[13]

[12] If final output is taken as numeraire, real wages are the same as monetary wages.

[13] The same variables also determine relative profits in the two sectors.

We summarize the "relative importance" of the two sectors by the parameter $x$:

$$x \equiv \frac{1-\gamma}{\gamma}\left(\frac{A_s}{A_f}\frac{p_s}{p_f}\right)^{\frac{1}{1-\alpha}} \tag{9}$$

which depends on the relative size, price and productivity of the two sectors. In what follows we assume that productivity, price and size of the two sectors are exogenous, and thus profits only depend on the labour force skill composition, $\delta$. This leaves little economic role for firms but allows us to concentrate on the firms' political role.[14] In the following sections, we will explain how $\delta$ is determined by the government's education policy and discuss why firms may lobby to influence the government's education policy to their advantage.

### 3.2 Education policy

The government chooses the education mix ($\delta$) to maximise a weighted sum of aggregate social welfare $\Delta$ and total lobby contributions $C$:

$$\Omega = \Delta + aC \tag{10}$$

where $a$ is the relative weight given by the government to lobby contributions.[15] The higher is $a$, the higher is government "affinity" for political contributions and the lower is its concern for social welfare.

As in the standard case of an utilitarian social welfare function, $\Delta$ is specified as the sum of total workers' wage income in the two sectors ($W_f = \gamma w_f$ and $W_s = (1-\gamma)w_s$) and firms' profits in the two sectors ($\Pi_f = \gamma\pi_f$ and $\Pi_s = (1-\gamma)\pi_s$). Specifically, we have that:

$$\Delta = W_f + W_s + \Pi_f + \Pi_s \tag{11}$$

[14] Having exogenous prices, is a clear, although in our context innocuous, simplification. What we have in mind is a non-competitive goods market structure. For example, assuming monopolistic competition, one could easily derive the relative price (see Baldwin and Robert-Nicoud, 2007, but also Acemoglu 2002). On the other hand, to endogenize firms' economic role in technology adoption and sector shift would require to specify a dynamic model, a task which we leave to future research.

[15] Notice that both $\Delta$ and $C$ depend on the educational policy, as it will be specified in the next sections.

Assuming that the "production function" of education is linear and that the unitary cost of producing type $F$ and type $S$ is the same, then, from the government's budget constraint, it is easy to see that this cost ($E$) determines the total amount to be spent on education.[16]

$$\delta E + (1-\delta)E = E \tag{12}$$

### 3.3 The social planner

We first analyze the case of $a = 0$, i.e. the government puts no weight on lobby contributions and it behaves as a benevolent social planner. In this case $\Omega = \Delta$ as defined at Eq. (11).

Using Eq.( 4), (5), (6), (7), the social planner's objective function can be rewritten as follows:

$$\Delta(\delta) = \gamma^{1-\alpha} A_f p_f \delta^{\alpha} + (1-\gamma)^{1-\alpha} A_s p_s (1-\delta)^{\alpha} \tag{13}$$

The efficient mix of the two types of education coincides with the decision of the social planner, who chooses $\delta$ in order to maximize Eq.(13). Solving the first order condition (see the appendix), and remembering the expression of $x$ at Eq. (9) we obtain the following level of $\delta$ :

$$\delta_{PL} = \frac{1}{1+x} \tag{14}$$

Obviously, $\delta_{PL}$ is decreasing in $x$: the higher is sector $s$ weight, relative to sector $f$, the more it is efficient to allocate resources to type $S$ education than to type $F$.

## 4 The lobbying game

The previous section has shown that the mix of the two types of education that would be chosen by the social planner depends on the "relative importance" of the two sectors in the economy, as measured by $x$. In this section, we analyze what happens when firms may get organized and exert their political power to induce the government to deviate from the efficient outcome in the attempt to obtain a more favorable value of $\delta$.

[16] One can imagine that education is financed by a lump-sum tax paid by workers and/or firms which does not affect their behaviour.

We assume that firms in both sectors may decide to be active in the lobbying process and, following Grossman and Helpman's (1994) seminal paper, we model lobbying as a "menu auction" (Bernheim and Whinston, 1986) in which interest groups offer contingent payments to the policy-maker in order to influence his action.[17] Moreover, lobbying is endogenous, as in Baldwin and Robert-Nicoud (2007): each lobby may decide to offer contributions to the government, which, simultaneously, decides whether to accept the contributions offered. The political equilibrium of this endogenous lobbying game represents the major novelty of our study. We also characterize the optimal mix of education at the equilibrium.

### 4.1 Lobbying

There are two organized groups, one representing firms in sector $s$, the other representing firms in sector $f$. Workers are politically not organized[18]. Lobbies offer political contributions to the government in order to influence its choice of the education mix and the government decides whether to accept them or not. We look at the conditions under which firms in each sector will find it convenient to invest in lobbying offering contributions to the government and the government, simultaneously, will decide whether to accept the contributions offered.

We indicate by $C_j(\delta)$ the payment offered by each firm in sector $j$ contingent on the government choice of $\delta$. Lobbying is costly: if the firm exerts lobby, it pays part of its profits as contributions to the government. We introduce two indicator functions: $I$, which can take only two values, $I_j = 1$ if sector $j$ offers contingent payments and $I_j = 0$ if it does not, and $G$, which can take only two values, $G_j = 1$ if the government accepts the contribution offered by sector $j$ and $G_j = 0$ if it does not accept it.[19] As in Grossman

[17] This is the so-called influence motive for lobbying. Lobbies can be also motivated by electoral motives, i.e. they might try to influence a candidate's chance of winning the election (see Grossman and Helpman, 2001 for a discussion). In this case, lobbies' contributions would be used to "buy" the vote of impressionable citizens (cfr. Grossman and Helpman, 1996). In our model we do not consider elections and restrict the attention to post-electoral lobbying.

[18] We find qualitatevely similar results if also workers exert lobby.

[19] As in Baldwin and Robert-Nicoud (2007), in our model at equilibrium the government always accepts

and Helpman (1994), contributions are restricted to be globally "truthful",[20] that is firms offer payments that reflect their true willingness to pay, i.e., for $j = f, s$ it is:

$$\frac{\partial C_j(\delta)}{\partial \delta} = \frac{\partial \pi_j(\delta)}{\partial \delta}$$

Truthful contribution functions offered by each firm in sector $j$ can thus be written as:

$$C_j(\delta) = \pi_j(\delta) - B_j \text{ if } I_j = 1; \text{ 0 otherwise} \tag{15}$$

where $B_j$ are scalars which represents the reservation utility of the firm and will be determined in the appendix, while proving proposition 1.

Total lobby contributions can thus be expressed as follows:

$$C(\delta) = \gamma G_f I_f C_f(\delta) + (1-\gamma) G_s I_s C_s(\delta) \tag{16}$$

### 4.2 Different cases of active lobbying

To determine the political equilibrium with endogenous lobbying, we first have to derive the optimal mix of education in the different cases of active lobbying, i.e. when both sectors are active, or when just one of the two sectors exerts lobby.

Consider first the case in which both sectors are active in the lobbying process, i.e. $G_j = I_j = 1$ for $j = f, s$. The government's objective function reduces to:

$$\Omega = \Delta + a[\gamma C_f(\delta) + (1-\gamma) C_s(\delta)]$$

Recalling Eq.(7), the first order condition with respect to $\delta$ can thus be written as follows:

$$\frac{\partial \Omega(\delta)}{\partial \delta} = \frac{\partial W_f(\delta)}{\partial \delta} + \frac{\partial W_s(\delta)}{\partial \delta} + \frac{\partial \Pi_f(\delta)}{\partial \delta} + \frac{\partial \Pi_s(\delta)}{\partial \delta} + a\left[\gamma \frac{\partial \pi_f(\delta)}{\partial \delta} + (1-\gamma)\frac{\partial \pi_s(\delta)}{\partial \delta}\right] \tag{17}$$

$$= \frac{\partial W_f(\delta)}{\partial \delta} + \frac{\partial W_s(\delta)}{\partial \delta} + (1+a)\left[\frac{\partial \Pi_f(\delta)}{\partial \delta} + \frac{\partial \Pi_s(\delta)}{\partial \delta}\right] \tag{18}$$

contributions. This is different from Felli and Merlo (2006), where the policymaker chooses the set of lobbies whom to bargain with excluding lobbies whose policy position is too close to its own.

[20] Bernheim and Winston (1996) show that if contribution functions are differentiable, they are locally truthful. They also show that equilibria based on truthful strategies not only exist but always result in an efficient choice of action. For situations in which non-binding communication is possible, these equilibria have a strong stability property, namely they are coalition-proof Nash. In other words, truthful equilibria are stable even if coalitions of players can communicate to devise a mutually preferable strategy.

This implies that the government behaves as if it were maximizing a weighted sum of workers wage (with weight equal to 1) and firms' profits (with weight $1+a$). Thus we have the following

**Result 1** *(Grossman and Helpman,1994) When both sectors are active in the lobbying process, the equilibrium mix of education spending is the same as the one that would be chosen by the social planner:* $\delta_{fs} = \delta_{PL} = \frac{1}{1+x}$.[21]

Intuitively, if the two lobbies have the same weight in the government's objective function, they lobby against each other and their political pressures exactly balance. This result suggests that a different weight between wages and profits in the government's objective function (i.e. the value of $a$) does not alter the composition of human capital as compared with what would be chosen by the social planner.

Suppose instead that only one sector is politically organized, for instance only the first sector exerts lobby. The government objective function becomes:

$$\Omega = W_f + W_s + \Pi_f + \Pi_s + a\gamma C_f \tag{19}$$

and the first order condition requires:

$$\frac{\partial \Omega(\delta)}{\partial \delta} = \frac{\partial W_f(\delta)}{\partial \delta} + \frac{\partial W_s(\delta)}{\partial \delta} + \frac{\partial \Pi_s(\delta)}{\partial \delta} + (1+a)\frac{\partial \Pi_f(\delta)}{\partial \delta} = 0 \tag{20}$$

Using Eq. (5), (4), (6), (7) and solving the first order condition, we obtain the following level of $\delta$:

$$\delta_f = \frac{1}{1+\eta} \tag{21}$$

where $\eta = x\left(\frac{1}{1+a(1-\alpha}\right)^{\frac{1}{1-\alpha}}$ .

Similarly, if only the second sector lobbies, we obtain the following level of $\delta$:

$$\delta_s = \frac{1}{1+\mu} \tag{22}$$

where $\mu = x\left[1+a(1-\alpha)\right]^{\frac{1}{1-\alpha}}$ .

[21] The equilibrium level of $\delta$ is given by solving the following first order condition:

$$\frac{\partial \Omega}{\partial \delta} = \alpha\gamma^{1-\alpha}A_f p_f \delta^{\alpha-1} + \alpha(1-\gamma)^{1-\alpha}A_s p_s (1-\delta)^{\alpha-1} + (1+a)(1-\alpha)[\gamma^{1-\alpha}A_f p_f \delta^{\alpha-1} + (1-\gamma)^{1-\alpha}A_s p_s (1-\delta)^{\alpha-1}] = 0$$

which delivers the same level $\delta_{PL}$ chosen by the social planner at Eq. (14).

Defining $\sigma = [1 + a(1-\alpha)]^{\frac{1}{1-\alpha}} > 1$, we can notice that $\eta = \frac{x}{\sigma}$ and $\mu = x\sigma$.

Thus, it is immediate to check that $\mu > x > \eta$ and thus $\delta_f > \delta_{PL} > \delta_s$. This shows the following

**Result 2** *(Grossman and Helpman, 1994) When only the sector using the first (second) type of education exerts lobby, more resources are directed towards the first (second) type of education with respect to the social planner solution.*

This is an intuitive result: when only one sector exerts lobby, it manages to attract more resources towards the type of education which is interesting for its production. With only one lobby, the weight given by government to contributions ($a$) affects the composition of human capital: the higher is $a$, the more the skill composition is twisted towards the lobby's favorite one.

### 4.3 Political equilibrium with endogenous lobbying

Il lobbying is endogenous, firms must decide whether (or not) it is worthwhile to set up a lobby and pay the contributions required to influence the government's education policy. A sector will get organized if profits, net of contributions, are higher if organized than if not.

Having in mind the results in the previous section, we can characterize the endogenous lobbying equilibrium.

**Proposition 1** *Active lobbying by both sectors is a Nash equilibrium of the political lobbying game.*

Intuitively, if one sector sets up a lobby to influence the government's choice, then the other sector is better off by doing the same. At equilibrium both sectors will lobby and the optimal mix of education coincides with the one chosen by the social planner.

### 4.4 Political equilibrium with costly lobbying

The result of active lobbying by both sectors at equilibrium is however not the end of the story. Organizing a lobby is costly: on top of payments for the administrative structure, expenditures are required for "establishing links with politicians, hiring professional

lobbyists, building a communications network among members, designing a scheme of punishments for defaulting members, etc" (see Mitra, 1999).

Assume that to get organized a group has to pay a cost $K > 0$ (equal for both sectors). In this case, an interest group may find it convenient to lobby only if its net benefit is larger than its cost. Having this in mind, and remembering that $x$ is our global indicator of the "relative importance" of the two sectors, based on relative size, price and productivity, we can prove the following result.

**Proposition 2** *If the two sectors have the same "relative importance" ($x = 1$), either firms in both sectors will exert lobby or none of them will do it. If the two sectors have a different relative importance ($x \neq 1$), there exists a level of $K$ of the lobbying cost such that only firms in the "relatively more important" sector will find it convenient to exert lobby (i.e. firms in sector $f$ when $x < 1$ and firms in sector $s$ when $x > 1$).*

The above proposition suggests that the relative importance of the two sectors matters to determine firms' net benefits from lobbying and thus, given the fixed cost, the decision on whether or not to set up a lobby. When only one sector exerts lobby, the equilibrium mix of education is different from the one decided by the social planner and, as we proved in proposition 2, the sector exerting lobbying is able to direct education expenditure in favor of the type of education that is needed for its production.

Given the expression of $x$, a sector's relative importance depends on its share in total output, its relative productivity and relative price. Thus, the influence that a sector has on the economy's composition of human capital can be attributed to its size, its market structure (price), its share of value added and its relative productivity. A small sector open to competition and less exposed to technical progress for instance might find it difficult to get organized, due to the limited amount of profits that can be used to "bribe" the policymaker. Moreover, size itself is important in determining a sector's decision on whether or not to lobby; in fact, given the fixed cost to be paid to organize a lobby, per-firm cost will be lower the higher the number of firms. This is of course due to our assumption that the cost is fixed and in particular it does not depend on the number of

firms belonging to a lobby.[22]

A natural interpretation of our results is given in case the two sectors differ for the type of technology adopted, low-technology and high-technology. In this case, proposition 2 suggests that, if the low-technology sector is the one which, due to its "relative importance", finds it convenient to exert lobby, it will also be able to direct public expenditure toward fields of education functional to a low-tech economy. Viceversa, if the high-technology sector is the one that finds it convenient to exert lobby, an equilibrium will emerge in which the type of education functional to technical progress and growth will be favoured.

Two natural extensions are worth mentioning at this point. First, one may want to allow for heterogeneity in the fixed cost because groups may differ in their organizational abilities (see Mitra, 1999) or "proximity" to the government (see Faccio, 2006). Obviously, the sector that has a smaller $K$ will, *ceteris paribus*, find it more convenient to exert lobby. Second, one may want to allow for heterogeneity in the weight attributed by the government to contributions paid by different groups. In both circumstances, even if the two sectors have the same importance ($x = 1$) it may be that only the sector "closer" to the government finds it convenient to get organized, and thus, to obtain that more resources are directed toward the type of education that it uses.

# 5 Concluding remarks

We have presented a two-sector political economy model in which individuals choose the type of education to acquire and the government's education policy affects this choice. In our setting, firms may lobby the policymaker in the attempt to obtain the desired supply of skill. Our purpose is to contribute to explain the observed differences in education systems and the relation between the composition of education and the structure of production.

As we know that firms may play a crucial role in financing education, as it is the case

[22] The assumption of fixed cost may seem quite restrictive, as some organizational cost are likely to increase with the number of firms. However what matters here is that the cost in per capita terms decreases as the number of firms increases.

for instance in US universities, we argue that a country's skill composition can be the result of lobbying activity by firms active in different sectors. We have shown that, if organizing a lobby is costly, an equilibrium might emerge in which firms in the "stronger" sector are able to bribe the policymaker and twist its choice of the education mix towards the type of skill needed in their production. Thus, lobbying may induce persistence in an economy's output composition.

As we pointed out before, our model is quite general and can be used to analyze many real situations. One example would be the case of traditional (low-technology) versus technology-driven industries. If the traditional sector is "stronger", then our model predicts that, under the influence of lobbying, a country might be trapped in a low-skill and low-technology specialization. Next, consider a country that to face competition on the global market is planning to change its productive specialization. Suppose that it wants to reduce the relative size of the financial sector and promote the so-called green economy. According to our result, if the financial sector, a top lobbyists in the US, is powerful enough, then, the status quo is likely to persist unless industrial policy is coordinated with education policy. To give yet another example, consider an established and relative sheltered sector vis-à-vis a new, highly innovative and potentially growing sector. Once again, without a proper policy (e.g. liberalization) or a shock that twists the balance of power in favor of the new sector, the status quo is bound to prevail.

An interesting application of the model would consider immigration policy. In this setting, the labor force consists of previously trained individuals and immigrants, i.e. individuals trained abroad. Our model would suggest that, under the influence of lobbying, countries specialized in high-tech sectors will favor the in-coming of highly qualified immigrants; on the contrary, countries with a structure of production mainly devoted to traditional sectors will be biased in favor of low-qualified immigrants.

A natural extension of our model would be to investigate into the causes which determine the relative importance of the two sectors $x$. In our framework, to move from one equilibrium to the other, an exogenous shock is needed. In a truly dynamic settings all the parameters influencing $x$ should be endogenized. In particular, innovation might differentially influence productivity in the two sectors and thus would be a natural candidate

as driving force for this dynamics. To move the equilibrium, technological progress would have to overcome the pressure for the status quo that comes from lobbying.

Our results also raise several crucial questions on the normative side: how can a country afford the challenge of globalization, if it does not attract talented individuals in fields of education which produce the skills needed in highly innovative and potentially growing sectors?[23]

Finally, in terms of policy implications, we suggest that education policy and the structure of education together with industrial policy should be given top priorities in the governments' agenda, and the role of lobbying activities by firms should not be neglected. In particular, countries should carefully consider the lobbying activity exerted by traditional sectors with low-technology specialization and its consequences on the industrial structure and the overall economy.

# 6 Appendix

## 6.1 The social planner

Recalling the social planner's objective function:

$$\Delta = \gamma^{1-\alpha} A_f p_f \delta^{\alpha} + (1-\gamma)^{1-\alpha} A_s p_s (1-\delta)^{\alpha}$$

its maximization delivers the following first order condition

$$\alpha\gamma^{1-\alpha} A_f p_f \delta^{\alpha-1} - \alpha(1-\gamma)^{1-\alpha} A_s p_s (1-\delta)^{\alpha-1} = 0$$

which can be rewritten as

$$\left(\frac{\delta}{1-\delta}\right)^{\alpha-1} = \frac{(1-\gamma)^{1-\alpha} A_s p_s}{\gamma^{1-\alpha} A_f p_f}$$

and thus

$$\delta = \delta_{PL} = \frac{1}{1 + \left(\frac{A_s p_s}{A_f p_f}\right)^{\frac{1}{1-\alpha}} \left(\frac{1-\gamma}{\gamma}\right)} = \frac{1}{1+x}$$

which corresponds to Eq.(14). Notice that $\delta_{PL} \in (0,1)$.

[23] As explained by Parente and Prescott (2000) the protection of specialized groups of factor suppliers and corporate interests through constraints relating to the use of technology may even be detrimental for growth.

## 6.2 Proof of proposition 1

To show that lobbying by both sectors is a Nash equilibrium, we have to check that if one sector lobbies then the other is better off by doing the same. We proceed in two steps: (i) compute the scalars $B_s$ and $B_f$ (ii) show that if firms in sector $f(s)$ are lobbying, then firms in sector $s(f)$ are better off by paying the contributions and have $\delta_{PL}$ rather than paying no contribution and having the level of $\delta$ that would be chosen if only the other sector would lobby.

(i) Computation of $B_s$ and $B_f$

To compute $B_s$, consider the case where only firms in the first sector exert lobby. In this case we know that the equilibrium mix of education spending is given by Eq.(21) with $\delta_f > \delta_{PL}$. If firms in sector $f$ pay contributions and the government accepts them, the government's objective function is:

$$\Omega(\delta_f) = \Delta(\delta_f) + a\gamma C_f(\delta_f) = \Delta(\delta_f) + a[\Pi_f(\delta_f) - \gamma B_f] \tag{23}$$

On the other hand, if both sectors exert lobby, then $\delta = \delta_{PL}$. In this case the government objective function is:

$$\Omega(\delta_{PL}) = \Delta(\delta_{PL}) + a[\gamma C_f(\delta_{PL}) + (1-\gamma)C_s(\delta_{PL})] = \Delta(\delta_{PL}) + a[\Pi_f(\delta_{PL}) - \gamma B_f + \Pi_s(\delta_{PL}) - (1-\gamma)B_s]$$

Thus, to induce the government to accept its contributions, sector $s$ should leave the government at least indifferent between $\Omega(\delta_f)$ and $\Omega(\delta_{PL})$ which requires

$$B_s = \frac{\Delta(\delta_{PL}) - \Delta(\delta_f) + a\left[\Pi_f(\delta_{PL}) - \Pi_f(\delta_f)\right] + a\Pi_s(\delta_{PL})}{a(1-\gamma)} \tag{24}$$

Each firm in sector $s$ will find it convenient to pay the contributions only if $\pi_s(\delta_{PL}) - C_s(\delta_{PL}) = B_s > \pi_s(\delta_f)$ i.e. if

$$a(1-\gamma)\left[B_s - \pi_s(\delta_f)\right] = \Delta(\delta_{PL}) - \Delta(\delta_f) + a\left[\Pi_f(\delta_{PL}) - \Pi_f(\delta_f)\right] + a\Pi_s(\delta_{PL}) - a\Pi_s(\delta_f) > 0 \tag{25}$$

Similarly, we can compute

$$B_f = \frac{\Delta(\delta_{PL}) - \Delta(\delta_s) + a\left[\Pi_s(\delta_{PL}) - \Pi_s(\delta_s)\right] + a\Pi_f(\delta_{PL})}{a\gamma}$$

Each firm in sector $f$ will find it convenient to pay the contributions only if $\pi_f(\delta_{PL}) - C_f(\delta_{PL}) = B_f > \pi_f(\delta_s)$ i.e. if

$$a\gamma\left[B_f - \pi_f(\delta_s)\right] = \Delta(\delta_{PL}) - \Delta(\delta_s) + a\left[\Pi_s(\delta_{PL}) - \Pi_s(\delta_s)\right] + a\Pi_f(\delta_{PL}) - a\Pi_f(\delta_s) > 0 \quad (26)$$

If the above conditions are satisfied, then, if sector $f(s)$ lobbies then sector $s(f)$ is better off by doing the same.

(ii) We now show that the above conditions for a Nash equilibrium are satisfied

Introducing the following generic expression for $\delta$:

$$\delta = \frac{1}{(1+d)} \quad (27)$$

(where $d = x$ if $\delta = \delta_{PL}$ ; $d = \eta$ if $\delta = \delta_f$ ; $d = \mu$ if $\delta = \delta_s$ )

we can rewrite the government objective function at Eq. (13) as

$$\Delta(\delta) = \gamma^{1-\alpha} A_f p_f \left(\frac{1}{1+d}\right)^{\alpha} \left[1 + \frac{d^{\alpha}(1-\gamma)^{1-\alpha} A_s p_s}{\gamma^{1-\alpha} A_f p_f}\right] \quad (28)$$

Using Eq. (27) into (6) and (7) we can also rewrite profits in the two sectors as:

$$\Pi_f(d) = \gamma^{1-\alpha}(1-\alpha) A_f p_f \left(\frac{1}{1+d}\right)^{\alpha} \quad (29)$$

and

$$\Pi_s(d) = (1-\gamma)^{1-\alpha}(1-\alpha) A_s p_s \left(\frac{d}{1+d}\right)^{\alpha} \quad (30)$$

Using Eq. (24), (5), (4), (6), (7) and choosing the appropriate value of $d$ in each case, Eq. (25) becomes:

$$\begin{aligned}
&\left(\frac{1}{1+x}\right)^{\alpha} \left[\gamma^{1-\alpha} A_f p_f + (1-\gamma)^{1-\alpha} A_s p_s x^{\alpha}\right] - \\
&\left(\frac{1}{1+\eta}\right)^{\alpha} \left[\gamma^{1-\alpha} A_f p_f + (1-\gamma)^{1-\alpha} A_s p_s \eta^{\alpha}\right] + \\
&a\left[\gamma^{1-\alpha}(1-\alpha)\left(\frac{1}{1+x}\right)^{\alpha} A_f p_f - \gamma^{1-\alpha}(1-\alpha)\left(\frac{1}{1+\eta}\right)^{\alpha} A_f p_f\right] + \\
&a\left[(1-\gamma)^{1-\alpha}(1-\alpha)\left(\frac{x}{1+x}\right)^{\alpha} A_s p_s - (1-\gamma)^{1-\alpha}(1-\alpha)\left(\frac{\eta}{1+\eta}\right)^{\alpha} A_s p_s\right] \\
> \; & 0
\end{aligned}$$

which, after some algebra con be rewritten as

$$\left[1 + a(1-\alpha)\right]\gamma^{1-\alpha} A_f p_f \left[\left(\frac{1}{1+x}\right)^{\alpha}\left(1 + \frac{x^{\alpha}(1-\gamma)^{1-\alpha} A_s p_s}{\gamma^{1-\alpha} A_f p_f}\right) - \left(\frac{1}{1+\eta}\right)^{\alpha}\left(1 + \frac{\eta^{\alpha}(1-\gamma)^{1-\alpha} A_s p_s}{\gamma^{1-\alpha} A_f p_f}\right)\right]$$

and, using the expression at Eq. (28), as

$$[1 + a(1 - \alpha)] [\Delta(\delta_{PL}) - \Delta(\delta_f)] > 0$$

which is clearly satisfied given that the function $\Delta(\delta)$ reaches its maximum at $\delta = \delta_{PL}$.

Similarly, we can easily check that $B_f - \pi_f(\delta_s) = [1 + a(1 - \alpha)] [\Delta(\delta_{PL}) - \Delta(\delta s)] > 0$. Q.E.D.

### 6.3 Proof of proposition 2

Remember that

$$a(1 - \gamma) [B_s - \pi_s(\delta_f)] = [1 + a(1 - \alpha)] [\Delta(\delta_{PL}) - \Delta(\delta_f)]$$

and

$$a\gamma [B_f - \pi_f(\delta_s)] = [1 + a(1 - \alpha)] [\Delta(\delta_{PL}) - \Delta(\delta_s)]$$

Given the (total) cost ($K$) of organizing a lobby, firms in sector $f$ will lobby if $B_f - \pi_f(\delta_s) > \frac{K}{\gamma}$ and firms in sector $s$ if $B_s - \pi_s(\delta_f) > \frac{K}{(1-\gamma)}$. Thus, using the above expressions, if $\Delta(\delta_f) = \Delta(\delta_s)$ either firms in sector $f$ and firms in sector $s$ all exert lobby, or none of them do it; if $\Delta(\delta_f) < \Delta(\delta_s)$ then there exists a level of $K$ such that only firms in sector $s$ exert lobby; finally, if $\Delta(\delta_f) > \Delta(\delta_s)$ then there exists a level of $K$ such that only firms in sector $f$ exert lobby. To compare $\Delta(\delta_f)$ and $\Delta(\delta_s)$ we use Eq. (28), i.e.

$$\Delta(\delta_f) = \gamma^{1-\alpha} A_f p_f \left(\frac{1}{1+\eta}\right)^{\alpha} \left[1 + \frac{\eta^{\alpha}(1-\gamma)^{1-\alpha} A_s p_s}{\gamma^{1-\alpha} A_f p_f}\right] \tag{31}$$

and

$$\Delta(\delta_s) = \gamma^{1-\alpha} A_f p_f \left(\frac{1}{1+\mu}\right)^{\alpha} \left[1 + \frac{\mu^{\alpha}(1-\gamma)^{1-\alpha} A_s p_s}{\gamma^{1-\alpha} A_f p_f}\right] \tag{32}$$

which, using $x = \frac{1-\gamma}{\gamma} \left(\frac{A_s p_s}{A_f p_f},\right)^{\frac{1}{1-\alpha}}$ can be rewritten as:

$$\Delta(\delta_f) = \gamma^{1-\alpha} A_f p_f \left(\frac{1}{1+\eta}\right)^{\alpha} \left[1 + \eta^{\alpha} x^{1-\alpha}\right] \tag{33}$$

and

$$\Delta(\delta_s) = \gamma^{1-\alpha} A_f p_f \left(\frac{1}{1+\mu}\right)^{\alpha} \left[1 + \mu^{\alpha} x^{1-\alpha}\right] \tag{34}$$

Thus, we have that:

(i) $\Delta(\delta_f) = \Delta(\delta_s)$ if $\left(\frac{1}{1+\eta}\right)^{\alpha}(1+\eta^{\alpha}x^{1-\alpha}) = \left(\frac{1}{1+\mu}\right)^{\alpha}(1+\mu^{\alpha}x^{1-\alpha})$. In this case either firms in both sectors lobby or none of them

(ii) $\Delta(\delta_f) > \Delta(\delta_s)$ if $\left(\frac{1}{1+\eta}\right)^{\alpha}(1+\eta^{\alpha}x^{1-\alpha}) > \left(\frac{1}{1+\mu}\right)^{\alpha}(1+\mu^{\alpha}x^{1-\alpha})$ In this case there exists a level of $K$ such that only firms in sector $f$ lobby

(iii) $\Delta(\delta_f) < \Delta(\delta_s)$ if $\left(\frac{1}{1+\eta}\right)^{\alpha}(1+\eta^{\alpha}x^{1-\alpha}) < \left(\frac{1}{1+\mu}\right)^{\alpha}(1+\mu^{\alpha}x^{1-\alpha})$ In this case there exists a level of $K$ such that only firms in sector $s$ lobby

Notice that, using $\eta = \frac{x}{\sigma}$ and $\mu = x\sigma$ we have that

$$\left(\frac{1}{1+\eta}\right)^{\alpha}(1+\eta^{\alpha}x^{1-\alpha}) = \frac{\sigma^{\alpha}+x}{(x+\sigma)^{\alpha}}$$

and

$$\left(\frac{1}{1+\mu}\right)^{\alpha}(1+\mu^{\alpha}x^{1-\alpha}) = \frac{1+\sigma^{\alpha}x}{(1+x\sigma)^{\alpha}}$$

where, as we know, $\alpha < 1$ and $\sigma = [1+a(1-\alpha)]^{\frac{1}{1-\alpha}} > 1$.

We thus have to compare the following two functions:

$$f(x) = \frac{\sigma^{\alpha}+x}{(x+\sigma)^{\alpha}}$$

and

$$g(x) = \frac{1+\sigma^{\alpha}x}{(1+x\sigma)^{\alpha}}$$

The three cases to be proved are thus:

(i) for $x = 1$, $f(x) = g(x)$ and thus $\Delta(\delta_f) = \Delta(\delta_s)$, i.e. either firms in both sectors lobby or none of them

(ii) for $x\epsilon(0,1)$, $f(x) > g(x)$ and thus $\Delta(\delta_f) > \Delta(\delta_s)$, i.e. there exists a level of $K$ such that only firms in sector $f$ lobby

(iii) for $x > 1$, $f(x) < g(x)$ and thus $\Delta(\delta_f) < \Delta(\delta_s)$ i.e. there exists a level of $K$ such that only firms in sector $s$ lobby

Result (i) is straightforward. For $x = 1$ we have that $f(1) = g(1) = \frac{1+\sigma^{\alpha}}{(1+\sigma)^{\alpha}}$.

To prove results (ii) and (iii) we proceed in 5 steps.

**STEP 1** It is sufficient to prove (ii), i.e. if $f(x) > g(x)$ for $x\epsilon(0,1)$ then $f(x) < g(x)$for $x > 1$,i.e. (iii) is satisfied.

This is because we can easily check that $f(\frac{1}{x}) - g(\frac{1}{x}) = x^{1-\alpha}\left[g(x) - f(x)\right]$. Thus, if for $x < 1$, $f(x) > g(x)$ we have that $f(\frac{1}{x}) < g(\frac{1}{x})$ which means that $f(y) < g(y)$ for any $y > 1$.

Thus, in what follows we restrict to $x\epsilon[0, 1]$

**STEP 2** $f(x)$ is increasing and concave.

We first calculate $f'(x)$ :

$$f'(x) = \frac{(\sigma + x) - \alpha(\sigma^{\alpha} + x)}{(\sigma + x)^{\alpha+1}} \tag{35}$$

which is always positive for $\alpha < 1$ and $\sigma > 1$.

The second derivative of $f(x)$ with respect to $x$ can be written as follows:

$$f''(x) = \frac{(1-\alpha)(\sigma + x)^{\alpha+1} - (\alpha + 1)(\sigma + x)^{\alpha}\left[x(1-\alpha) + (\sigma - \alpha\sigma^{\alpha})\right]}{(x + \sigma)^{2\alpha+2}}$$

which, after simple algebra, becomes

$$f''(x) = \frac{-\alpha x(1-\alpha) - \alpha\sigma\left[2 - \sigma^{\alpha-1}(1-\alpha)\right]}{(x + \sigma)^{\alpha+2}}$$

which is negative given that $2 - \sigma^{\alpha-1}(1-\alpha) > 0$ for $\sigma > 1$ and $\alpha < 1$.

Notice that having $f(x)$ always increasing implies that $f(1) = g(1) = \frac{1+\sigma^{\alpha}}{(1+\sigma)^{\alpha}} > f(0) = g(0) = 1$

**STEP 3** Function $g(x)$ is either always increasing (if $\sigma^{\alpha} > \alpha\sigma$), or it has a minimum at $\overline{x} = \frac{\alpha\sigma - \sigma^{\alpha}}{\sigma^{\alpha+1}(1-\alpha)}$ (if $\sigma^{\alpha} < \alpha\sigma$).

We first calculate $g'(x)$:

$$g'(x) = \frac{\sigma^{\alpha}(1 + \sigma x) - \alpha\sigma(1 + \sigma^{\alpha}x)}{(1 + \sigma x)^{\alpha+1}} \tag{36}$$

which delivers the result at step 3.

**STEP 4** $g(x)$ is concave for $x > \widehat{x} = \frac{\alpha+1-2\sigma^{\alpha-1}}{\sigma^{\alpha}(1-\alpha)}$ and convex for $x < \widehat{x}$ with $\overline{x} < \widehat{x} < 1$.

The second derivative of $g(x)$ with respect to $x$ can be written as follows:

$$g''(x) = \frac{\sigma^{\alpha+1}(1-\alpha)(1 + \sigma x)^{\alpha+1} - \sigma(\alpha + 1)(1 + \sigma x)^{\alpha}\left[\sigma^{\alpha+1}x(1-\alpha) + \sigma^{\alpha} - \alpha\sigma\right]}{(1 + \sigma x)^{2\alpha+2}}$$

which, after simple algebra, becomes:

$$g''(x) = \frac{-(1-\alpha)\sigma^{\alpha+1}x - 2\sigma^{\alpha} + (\alpha + 1)\sigma}{(1 + \sigma x)^{\alpha+2}}\alpha\sigma$$

which is equal to zero at $x = \widehat{x}$, it is positive for $x < \widehat{x}$ and negative for $x > \widehat{x}$.

Again, given that $\alpha < 1$ and $\sigma > 1$ it is easy to check that $\overline{x} < \widehat{x} < 1$.

**STEP 5** $f'(0) > g'(0)$ and $f'(1) < g'(1)$.

This result can be more easily shown starting from the following equivalence:

$$\frac{\partial}{\partial x} \log f(x) = \frac{f'(x)}{f(x)}$$

where $f'(x) = \frac{\partial}{\partial x} f(x)$. Thus

$$\begin{aligned} f'(x) &= f(x)\frac{\partial}{\partial x} \log f(x) = f(x)\frac{\partial}{\partial x} \left[\log(x + \sigma^\alpha) - \alpha \log(x + \sigma)\right] = \\ & f(x) \left[\frac{1}{x + \sigma^\alpha} - \frac{\alpha}{x + \sigma}\right] \end{aligned} \tag{37}$$

and

$$\begin{aligned} g'(x) &= g(x)\frac{\partial}{\partial x} \log g(x) = g(x)\frac{\partial}{\partial x} \left[\log(1 + \sigma^\alpha x) - \alpha \log(1 + \sigma x)\right] = \\ & g(x) \left[\frac{\sigma^\alpha}{1 + \sigma^\alpha x} - \frac{\alpha\sigma}{1 + \sigma x}\right] \end{aligned} \tag{38}$$

Evaluating $f'$ at Eq.(35) and $g'$ at Eq. (36) at $x = 0$ we have that

$$\begin{aligned} f'(0) &= f(0) \left[\frac{1}{\sigma^\alpha} - \frac{\alpha}{\sigma}\right] = \left[\frac{1}{\sigma^\alpha} - \frac{\alpha}{\sigma}\right] \\ g'(0) &= g(0) \left[\sigma^\alpha - \alpha\sigma\right] = \left[\sigma^\alpha - \alpha\sigma\right] \end{aligned}$$

For $\sigma^\alpha < \alpha\sigma$, $g'(0) < 0$ and thus $g'(0) < 0 < f'(0)$.For $\sigma^\alpha > \alpha\sigma$, we can prove, using Mathematica, that $\frac{f'(0)}{g'(0)} = \frac{\left[\frac{1}{\sigma^\alpha} - \frac{\alpha}{\sigma}\right]}{\left[\sigma^\alpha - \alpha\sigma\right]} > 1$ for any value of the parameters $\alpha, \sigma$.

Evaluating $f'$ at Eq.(35) and $g'$ at Eq. (36) at $x = 1$ we have that

$$\begin{aligned} f'(1) &= f(1) \left[\frac{1}{1 + \sigma^\alpha} - \frac{\alpha}{1 + \sigma}\right] \\ g'(1) &= g(1) \left[\frac{\sigma^\alpha}{1 + \sigma^\alpha} - \frac{\alpha\sigma}{1 + \sigma}\right] \end{aligned}$$

Using $f(1) = g(1) = \frac{1+\sigma^\alpha}{(1+\sigma)^\alpha}$ after simple algebra we can write

$$\frac{g'(1)}{f'(1)} = \frac{\sigma^\alpha(1 + \sigma) - \alpha\sigma(1 + \sigma^\alpha)}{1 + \sigma - \alpha(1 + \sigma^\alpha)}$$

which, using Mathematica can be proved to be always greater than 1 for any value of the parameters $\alpha, \sigma$.

To sum up, we have considered the two functions $f$ and $g$ , which reach the same value at $x = 0$ and $x = 1$. In the interval $(0, 1)$ function $f$ is always increasing and concave, function $g$ may either be always increasing or first decreasing and then increasing. However, given that at $x = 0$ function $f$ has a derivative higher than function $g$, function $f$ starts above function $g$. Since they never cross again before $x = 1$, function $f$ remains above function $g$ till $x = 1$. Given that at $x = 1$ instead function $g$ has a higher derivative than $f$ and both are concave at that point, function $g$ crosses function $f$ at $x = 1$. We have also proved that having $f$ above $g$ for the interval $(0, 1)$ also implies that $f$ is below $g$ for $x > 1$. Q.E.D.

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**Table 1: Expenditure in education**

| | Expenditures in education as % of GDP | | | | Total expenditures per student US$PPP (a) | Graduates in upper secondary general programmes (b) | Graduation rate Tertiary-type A programmes (first degree) |
|---|---|---|---|---|---|---|---|
| | Primary, secondary and post-secondary non-tertiary education | Tertiary education | Total (public and private) all level of education | Total (public) all level of education | | | |
| Australia | 3,5 | 1,5 | 5,2 | 3,8 | 8.786 | 62,6 | 59,2 |
| Austria | 3,6 | 1,3 | 5,4 | 5,1 | 10.974 | 18,6 | 25,0 |
| Belgium | 4,1 | 1,3 | 6,1 | 5,9 | 9.162 | 34,4 | 27,8 |
| Canada | 3,5 | 2,6 | 6,1 | 4,6 | m | 90,7 | 40,0 |
| Czech Republic | 2,8 | 1,2 | 4,6 | 4,1 | 5.426 | 24,7 | 37,3 |
| Denmark | 4,3 | 1,7 | 7,1 | 6,6 | 10.759 | 53,3 | 46,5 |
| Finland | 3,6 | 1,6 | 5,6 | 5,5 | 8.440 | 35,6 | 82,0 |
| France | 3,9 | 1,4 | 6,0 | 5,5 | 8.932 | 45,2 | 35,4 |
| Germany | 3,0 | 1,1 | 4,7 | 4,0 | 8.270 | 42,7 | 25,5 |
| Greece | m | m | m | m | m | 68,8 | 23,6 |
| Hungary | 3,2 | 0,9 | 4,9 | 4,9 | 4.811 | 79,8 | 34,3 |
| Iceland | 5,1 | 1,2 | 7,8 | 7,0 | 9.015 | 54,3 | 57,4 |
| Ireland | 3,48 | 1,2 | 4,7 | 4,4 | 8.628 | 55,9 | 46,1 |
| Italy | 3,1 | 0,9 | 4,5 | 4,1 | 7.948 | 34,6 | 32,8 |
| Japan | 2,8 | 1,5 | 4,9 | 3,3 | 9.312 | 75,6 | 39,4 |
| Korea | 4,0 | 2,4 | 7,0 | 4,2 | 7.325 | 72,7 | 43,4 |
| Luxembourg | 3,1 | m | m | m | m | 38,8 | 5,3 |
| Mexico | 3,8 | 1,2 | 5,7 | 4,7 | 2.598 | 92,2 | 18,1 |
| Netherlands | 3,7 | 1,5 | 5,6 | 4,7 | 9.883 | 34,6 | 44,7 |
| New Zealand | 4,0 | 1,5 | 5,9 | 4,8 | 6.226 | m | 50,7 |
| Norway | 3,7 | 1,3 | 5,5 | 5,4 | 11.967 | 59,6 | 44,9 |
| Poland | 3,4 | 1,3 | 5,3 | 4,8 | 4.134 | 62,3 | 50,0 |
| Portugal | 3,5 | 1,6 | 5,6 | 5,1 | 6.677 | 67,6 | 45,3 |
| Slovak Republic | 2,5 | 0,9 | 4,0 | 3,4 | 3.694 | 25,7 | 57,1 |
| Spain | 2,9 | 1,1 | 4,8 | 4,2 | 8.618 | 53,9 | 29,8 |
| Sweden | 4,1 | 1,6 | 6,3 | 6,1 | 10.262 | 43,5 | 39,2 |
| Switzerland | 4,0 | 1,2 | 5,5 | 5,1 | 13.031 | 30,4 | 30,4 |
| Turkey | m | m | m | m | m | 66,4 | 19,7 |
| United Kingdom | 4,2 | 1,3 | 5,8 | 5,2 | 9.600 | 100,0 | 40,1 |
| United States | 4,0 | 3,1 | 7,6 | 5,0 | 14.269 | 100,0 | 37,3 |

(a) Public institution only for Hungary, Poland, Portugal, Switzerland and Italy (except in tertiary education).

(b) For United Kingdom and United States, year of reference is 2006.

Expenditures on Education as % of GDP (year 2007): Education at Glance, 2010.

Expenditures per student US$PPP based on full-time equivalents (year 2007): Education at Glance, 2010.

Graduates in upper secondary general programmes (year 2008): Oecd.stat - Education and training

Graduation rate (year 2008): Education at a Glance, 2010

**Table 2. Tertiary education**

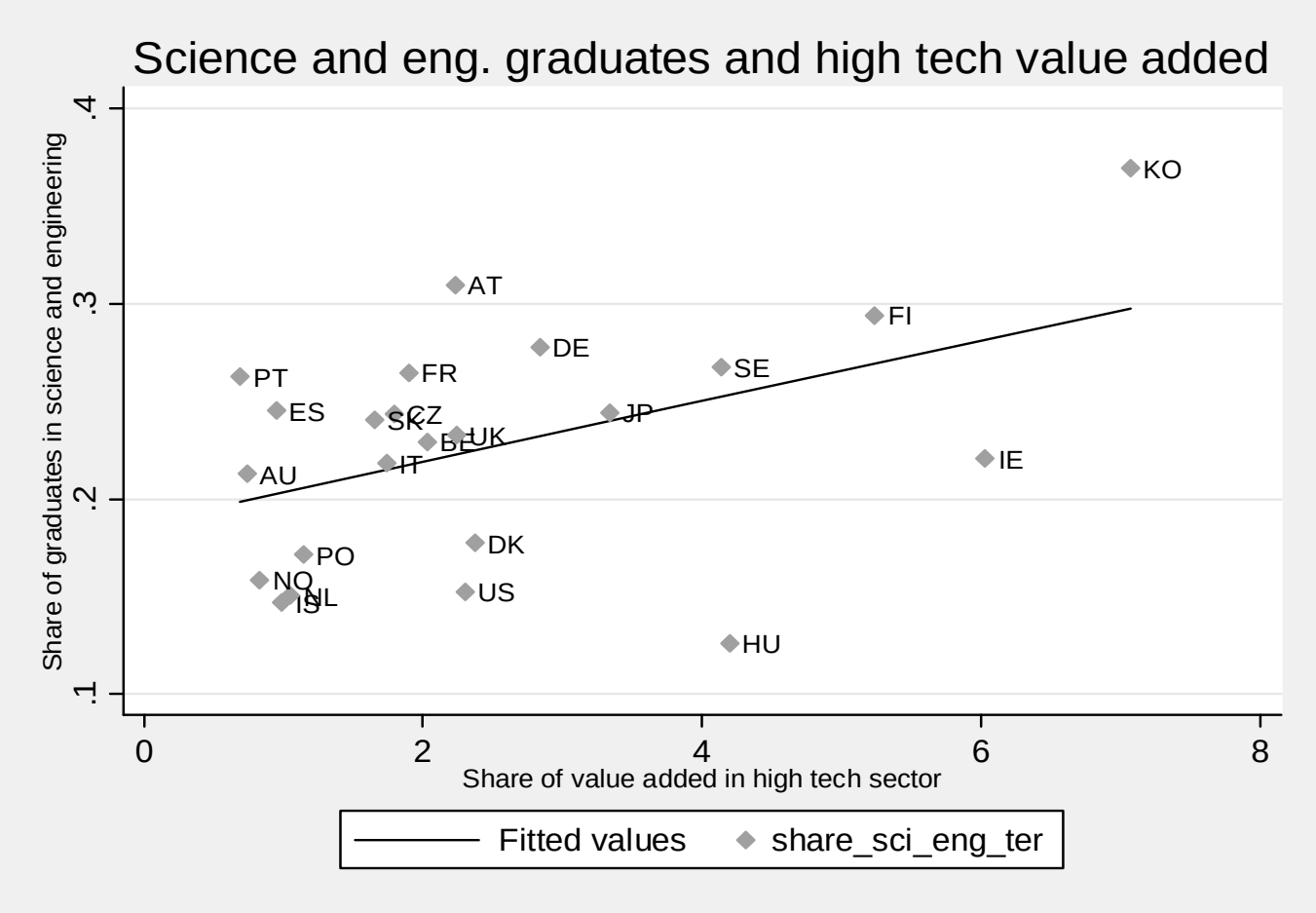
| | Tertiary-type A and advanced research programmes (2008) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Shares over all fields of study | | | | | | | |
| | Education | Humanities and Arts | Social sciences business and law | Science | Engineering manufacturing and construction | Agriculture | Health and welfare | Services |
| **Australia** | 0,11 | 0,11 | 0,43 | 0,12 | 0,07 | 0,01 | 0,15 | 0,03 |
| **Austria** | 0,11 | 0,10 | 0,39 | 0,13 | 0,14 | 0,01 | 0,10 | 0,02 |
| **Belgium** | 0,05 | 0,17 | 0,36 | 0,07 | 0,13 | 0,03 | 0,16 | 0,01 |
| **Canada** | 0,11 | 0,13 | 0,37 | 0,13 | 0,08 | 0,01 | 0,10 | 0,03 |
| **Czech Republic** | 0,16 | 0,07 | 0,32 | 0,10 | 0,17 | 0,04 | 0,07 | 0,04 |
| **Denmark** | 0,09 | 0,15 | 0,28 | 0,08 | 0,12 | 0,01 | 0,26 | 0,01 |
| **Finland** | 0,08 | 0,17 | 0,26 | 0,12 | 0,15 | 0,02 | 0,15 | 0,05 |
| **France** | 0,02 | 0,14 | 0,42 | 0,14 | 0,13 | 0,01 | 0,10 | 0,04 |
| **Germany** | 0,09 | 0,22 | 0,27 | 0,16 | 0,12 | 0,01 | 0,09 | 0,02 |
| **Greece** | 0,12 | 0,18 | 0,32 | 0,14 | 0,12 | 0,03 | 0,08 | 0,01 |
| **Hungary** | 0,19 | 0,09 | 0,39 | 0,06 | 0,08 | 0,02 | 0,10 | 0,08 |
| **Iceland** | 0,21 | 0,10 | 0,39 | 0,06 | 0,07 | 0,00 | 0,15 | 0,02 |
| **Ireland** | 0,09 | 0,20 | 0,34 | 0,13 | 0,08 | 0,01 | 0,14 | 0,01 |
| **Italy** | 0,06 | 0,16 | 0,36 | 0,07 | 0,15 | 0,02 | 0,15 | 0,03 |
| **Japan** | 0,06 | 0,17 | 0,35 | 0,05 | 0,19 | 0,03 | 0,08 | 0,02 |
| **Korea** | 0,10 | 0,19 | 0,23 | 0,10 | 0,23 | 0,02 | 0,09 | 0,04 |
| **Luxembourg** | 0,00 | 0,15 | 0,48 | 0,29 | 0,04 | 0,00 | 0,00 | 0,02 |
| **Mexico** | 0,14 | 0,04 | 0,42 | 0,10 | 0,14 | 0,02 | 0,10 | 0,03 |
| **Netherlands** | 0,15 | 0,09 | 0,37 | 0,06 | 0,08 | 0,01 | 0,18 | 0,05 |
| **New Zealand** | 0,14 | 0,16 | 0,40 | 0,13 | 0,07 | 0,01 | 0,17 | 0,01 |
| **Norway** | 0,18 | 0,09 | 0,29 | 0,08 | 0,08 | 0,01 | 0,24 | 0,05 |
| **Poland** | 0,17 | 0,08 | 0,43 | 0,08 | 0,09 | 0,02 | 0,09 | 0,05 |
| **Portugal** | 0,09 | 0,10 | 0,32 | 0,15 | 0,22 | 0,03 | 0,21 | 0,07 |
| **Slovak Republic** | 0,17 | 0,06 | 0,31 | 0,08 | 0,13 | 0,02 | 0,17 | 0,05 |
| **Spain** | 0,15 | 0,09 | 0,29 | 0,10 | 0,14 | 0,02 | 0,16 | 0,05 |
| **Sweden** | 0,21 | 0,06 | 0,24 | 0,07 | 0,17 | 0,01 | 0,27 | 0,01 |
| **Switzerland** | 0,12 | 0,13 | 0,37 | 0,12 | 0,12 | 0,01 | 0,10 | 0,02 |
| **Turkey** | 0,24 | 0,06 | 0,41 | 0,09 | 0,09 | 0,03 | 0,06 | 0,02 |
| **United Kingdom** | 0,10 | 0,18 | 0,34 | 0,14 | 0,09 | 0,01 | 0,14 | 0,01 |
| **United States** | 0,12 | 0,16 | 0,40 | 0,09 | 0,06 | 0,01 | 0,11 | 0,06 |

**Table 3. Value added by sectors of production**

| Value added shares relative to total economy. | TOTAL | | | | | | | | | TOTAL SERVICES | HITECH High-technology manufactures | HMHTECH High and medium-high technology manufactures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AGRICULTURE HUNTING, FORESTRY AND FISHING | MINING AND QUARRYING | MANUFACTURING | ELECTRICITY GAS AND WATER SUPPLY | CONSTRUCTION | WHOLESALE AND RETAIL TRADE - RESTAURANTS AND HOTELS | TRANSPORT, STORAGE AND COMMUNICATIONS | FINANCE, INSURANCE REAL ESTATE AND BUSINESS SERVICES | COMMUNITY SOCIAL AND PERSONAL SERVICES | | | |
| Australia | 2,3 | 7,8 | 11,2 | 2,3 | 7,4 | 13,1 | 7,7 | 29,6 | 18,6 | 69,0 | 0,7 | 3,1 |
| Austria | 1,7 | 0,5 | 20,0 | 2,4 | 6,9 | 17,3 | 6,2 | 24,3 | 20,8 | 68,6 | 2,2 | 8,4 |
| Belgio | 0,9 | 0,1 | 16,7 | 2,2 | 5,1 | 14,5 | 8,4 | 28,8 | 23,4 | 75,1 | 2,0 | 6,9 |
| Czech Republic | 2,6 | 1,3 | 26,3 | 4,3 | 6,3 | 14,9 | 10,7 | 16,4 | 17,3 | 59,2 | 1,8 | 11,1 |
| Denmark | 1,3 | 4,1 | 14,2 | 2,1 | 5,7 | 14,1 | 7,7 | 24,2 | 26,6 | 72,5 | 2,4 | 6,2 |
| Finland | 2,7 | 0,4 | 23,7 | 2,3 | 6,0 | 12,0 | 10,1 | 20,8 | 22,1 | 64,9 | 5,2 | 10,8 |
| France | 2,1 | 0,0 | 12,8 | 1,7 | 6,0 | 12,6 | 6,4 | 33,7 | 24,9 | 77,5 | 1,9 | 5,3 |
| Germany | 0,9 | 0,2 | 23,4 | 2,4 | 3,9 | 11,7 | 5,8 | 29,2 | 22,4 | 69,2 | 2,8 | 13,4 |
| Greece | 3,9 | 0,5 | 10,2 | 2,6 | 6,7 | 24,2 | 9,4 | 18,6 | 23,9 | 76,1 | 0,5 | 1,9 |
| Hungary | 4,1 | 0,2 | 22,5 | 2,6 | 4,8 | 13,1 | 7,7 | 22,3 | 22,8 | 65,9 | 4,2 | 11,9 |
| Iceland | 6,3 | 0,0 | 10,9 | 3,9 | 11,3 | 11,5 | 6,3 | 26,0 | 23,7 | 67,5 | 1,0 | 2,0 |
| Ireland | 1,6 | 0,5 | 22,1 | 1,2 | 10,2 | 13,1 | 5,3 | 27,7 | 18,3 | 64,4 | 6,0 | 12,8 |
| Italy | 2,1 | 0,4 | 18,7 | 2,1 | 6,1 | 15,3 | 7,4 | 26,9 | 21,0 | 70,7 | 1,7 | 6,9 |
| Japan | 1,4 | 0,1 | 20,7 | 3,2 | 6,1 | 17,0 | 6,4 | 26,7 | 18,4 | 68,5 | 3,3 | 10,6 |
| Korea | 3,3 | 0,3 | 28,0 | 2,3 | 9,0 | 9,8 | 7,1 | 21,2 | 19,0 | 57,1 | 7,1 | 16,2 |
| Luxembourg | 0,4 | 0,1 | 8,7 | 1,2 | 5,8 | 11,0 | 8,7 | 48,5 | 15,6 | 83,9 | .. | 1,6 |
| Netherlands | 2,2 | 3,3 | 13,9 | 1,9 | 5,5 | 14,8 | 7,1 | 27,7 | 23,6 | 73,2 | 1,1 | 5,3 |
| New Zealand | 5,4 | 1,3 | 14,5 | 2,8 | 5,5 | 14,6 | 7,2 | 29,9 | 18,9 | 70,6 | .. | .. |
| Norway | 1,5 | 27,8 | 10,0 | 2,6 | 4,5 | 9,5 | 7,5 | 17,0 | 19,7 | 53,7 | 0,8 | .. |
| Poland | 4,3 | 2,4 | 18,8 | 3,5 | 6,4 | 20,1 | 7,4 | 18,3 | 18,9 | 64,6 | 1,1 | 6,0 |
| Portugal | 2,8 | 0,0 | 14,8 | 2,9 | 6,6 | 17,3 | 7,0 | 22,0 | 26,5 | 72,9 | 0,7 | 3,2 |
| Slovak Republic | 3,6 | 0,4 | 24,1 | 6,8 | 7,7 | 16,7 | 7,2 | 17,6 | 15,9 | 57,4 | 1,6 | 8,2 |
| Spain | 2,8 | 0,3 | 15,5 | 2,0 | 12,1 | 18,0 | 6,9 | 21,7 | 20,8 | 67,4 | 0,9 | 5,2 |
| Sweden | 1,4 | 0,6 | 19,7 | 2,8 | 4,7 | 12,6 | 7,3 | 25,4 | 25,3 | 70,6 | 4,1 | 10,3 |
| Switzerland | 1,2 | 0,2 | 19,8 | 2,0 | 5,6 | 15,5 | 6,4 | 29,4 | 19,9 | 71,2 | .. | 11,6 |
| United Kingdom | 0,7 | 2,7 | 13,0 | 1,6 | 6,3 | 14,4 | 6,9 | 31,0 | 23,4 | 75,7 | 2,2 | 5,5 |
| United States | 0,9 | 2,0 | 13,0 | 2,1 | 4,9 | 15,2 | 5,9 | 32,5 | 23,6 | 77,1 | 2,3 | 5,6 |

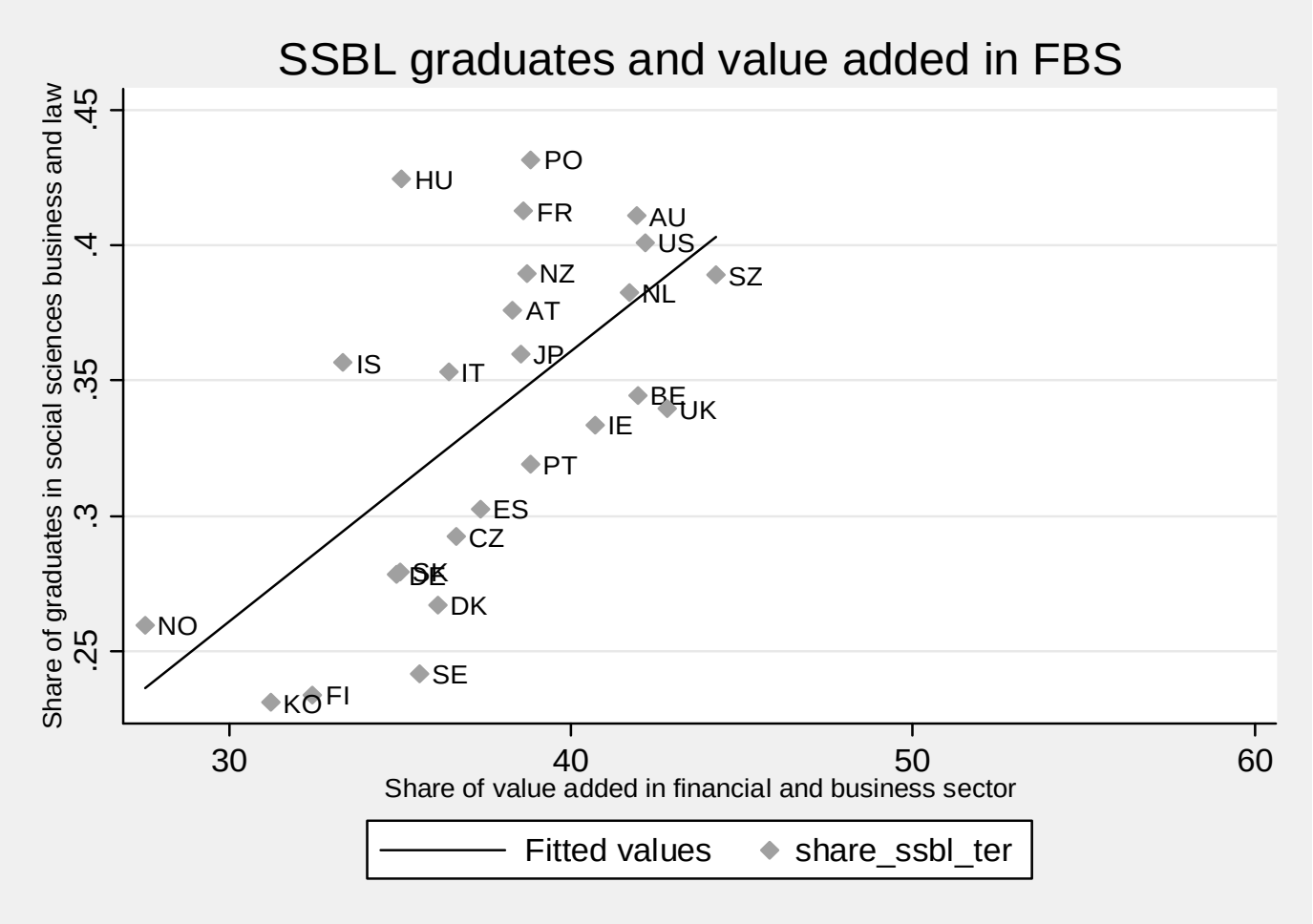
Source: OECD Stan Indicators 2009

**Figure 1: Graduates in science and engineering and value added in high tech**




Corr. 0.46; R2=0.21

**Figure 2: Graduates in social science, business and law and value added in finance and business services**




Corr. 0.63 ; R2=0.40