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Polarization in Higher Education and Technological Leadership

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Abstract

This paper shows that polarization in higher education, characterized by a widening gap between elite and non-elite institutions, can influence a nation's technological leadership and its level of inequality. Higher education polarization refers to the widening gap between elite and non-elite universities, primarily in two dimensions: the level of academic standards and the selectivity of student admissions.

This paper underlines that a country with a high degree of polarization in their higher education systems can achieve technological dominance but also experience increased inequality.

In the empirical analysis, we construct indices that measure the polarization gap both in the level of academic standards and the selectivity of student admissions, as well as an index for leadership in technology. The findings reveal a positive correlation between the polarization gap, technological leadership, and inequality among OECD countries.

In consequence, this paper shows that a nation implementing a public education policy, which establishes polarization in higher education may stimulate progress and technological leadership, at the price of inequality.

Keywords: polarization; skills; higher education; technological leadership; inequality.

JEL classification: I23, I24, J24, O14, O40.

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I. Introduction

This paper shows that polarization in higher education, defined as a widening gap between elite and non-elite institutions, may affect a nation's technological leadership and its level of inequality. In this context, polarization refers to divergence along two main dimensions: (i) academic standards and research performance, and (ii) the selectivity of student admissions.

While in the literature on inequality and economic growth, higher education is characterized as one homogeneous element, in fact, higher education institutions are heterogenous and consists of two channels: graduating from a prestigious and elite university or graduating from a standard one.

This paper exposes theoretically and empirically two main differences between standard and elite universities. First, knowledge disseminated in elite universities is at the frontier of technology, since due to high budgets, they can afford top scholars, good labs and infrastructure. Second, recruitment for elite universities is highly selective. We show that this double gap between universities, in the level of academic standards and the selectivity of student admissions, may explain the difference in leadership and inequality among countries.

The heterogeneity in higher education affects leadership in technology because workers are not similar in their capability. In this paper, we depart from the assumption of homogeneity of skilled workers: there are workers which are with high potential, and some with low potential. In consequence, there is a double heterogeneity in the model which tries to fit the reality. First, individuals are heterogeneous in their capabilities – some are abler than others. Second, and not less important, skills are acquired through institutions which are different in their academic standard. Considering this double heterogeneity, in level of universities, and in capabilities of individuals will affect the equilibrium of the economy and will affect leadership in technology and inequality among workers.

This paper will relate the heterogeneity in capabilities to the second dimension of polarization, which concerns the selectivity of student admissions. Indeed, we show that this second polarization gap between elite and non-elite universities enables the distinction between individuals with strong and weaker academic potential, so that only high-potential students graduate from top universities. In consequence, the polarization gap in higher education leads to an equilibrium in which students with high academic potential graduate from elite institutions, while others attend standard ones.

The paper also emphasizes the supply side of the economy. Polarization in higher education matters for technological leadership because the production of high-tech goods generates strong knowledge spillovers, unlike the production of low-tech goods. As a result, allocating the most capable workers to knowledge-intensive activities yields much larger productivity gains than assigning them to low-tech sectors.

In this framework, graduates of elite institutions tend to be more productive than they would have been had they attended a standard university, not only because of selection, but also because top universities operate at the frontier of knowledge and transmit cutting-edge ideas and methods. Those skills and insights are then applied where they have the highest return: the high-tech sector.

The central mechanism is therefore the match between high capability, elite education, and employment in high-tech sectors. This matching process is essential to understanding both technological leadership and the evolution of inequality.

In the empirical part, this paper constructs novel indices to measure the polarization gap in higher education across countries. There are two indices of polarization; the first is about academic standard and the second one is about selectivity of student recruitment. The first index captures the gap in quality between elite and standard universities by comparing budgets per student, using data from leading institutions identified by international rankings. Countries with larger budget disparities tend to have more pronounced differences in the level of academic standard offered, which is a core driver of polarization.

The second index measures the selectivity of student admissions, capturing how competitive entry is at elite universities relative to standard institutions. For each country in our sample, we collected admission rates for elite and standard universities; the ratio of these rates defines our selectivity index. This index thus quantifies how much more selective top institutions are than standard universities.

In addition to these two indices of polarization in higher education, the empirical analysis develops a new leadership index for technology. This composite index combines R&D expenditure as a percentage of GDP with patents per capita, reflecting a country's capacity for innovation and technological advancement. Countries are benchmarked relative to the United States, which anchors the scale. Our index for inequality is the Gini index, although in our theoretical part, inequality is defined more narrowly as the gap in wages between skilled workers, who graduate from elite universities and those who graduate from standard institutions.

The model has shown that these differences between universities affect inequality and leadership in technology. In consequence, the econometric analysis then examines the relationship between the polarization indices, technological leadership, and inequality. The results show that countries with a wider polarization gap in both academic standard and recruitment tend to achieve higher levels of technological leadership but also experience greater wage inequality.

Overall, the empirical evidence establishes that a more polarized higher education system supports leadership in technology but at the cost of higher inequality. There is a trade-off between inequality and seeking to establish leadership in technology.

This paper is divided into two main parts: a theoretical model and an empirical section. The empirical section presents the two indices measuring the polarization gap for 17 OECD countries, based on the data of hundreds of universities. The paper is divided into five sections. In the next section, we review the literature. The model is presented in section III. Section IV presents the empirical analysis. Section V concludes.

II. Related Literature

2.1 Leadership in technology

Determining a country's leadership in technology involves considering various indicators and data points. In the literature, there is no single metric that definitively establishes technological leadership, and many indices are used as indicators to assess a country's strength in the technology sector. One strategy is to focus on Research and Development (R&D) spending. Some work focuses on total R&D spending, while others focus on main sectors (see Huang and Sharif, 2015 and Nelson and Wright, 1992). Another strategy is focusing on the number of patents granted since a high volume of patents suggests a strong focus on technological development (see Nelson, 1990).

An alternative approach is based on the contribution of technology-related industries to the country's business output, which reflects its economic reliance on leadership in the technology sector (see Fernando and Fabien, 2016). Moreover, there is another line of literature developing various global indices, such as the Global Innovation Index (GII) and the Global Competitiveness Index (GCI), which assess, and rank countries based on their innovation and technology capabilities.[1]

Recent studies have also connected technological leadership to the emergence of 'superstar firms', showing how advanced industries increasingly rely on top talent from elite institutions, further concentrating productivity and wages at the top (Autor et al., 2020). Likewise, Andrews and Criscuolo (2013) stress that access to high-level skills is essential for firm-level innovation performance.

Some research, such as Jaunee (2016), focuses on venture capital (VC) activity and investment in startups which indicate a thriving technology ecosystem. Indeed, countries with a high level of VC funding often foster innovation and entrepreneurship. Similarly, the presence and growth of technology startups, particularly in sectors like artificial intelligence, biotechnology, and information technology, are key indicators of technological leadership. Similarly, the existence of

[1] https://www.wipo.int/global_innovation_index/en/2023/ and https://databank.worldbank.org/metadataglossary/

innovation hubs, technology parks, and incubators that support the growth of technology companies and startups is a positive indicator.

An opposite view is to focus not on startup but on established and big companies and analyse the Global Tech Company Headquarters. The presence of global technology giants headquartered in a country is a sign of its influence in the tech sector. Another index of leadership could be to focus on Advanced information and communication technology (ICT) infrastructure since widespread connectivity contribute to a country's technological leadership, enabling the adoption of emerging technologies.

More indices that are common in the literature are "Exports of high-tech out of total exports", and "percent of scientists in the population" (Nelson and Wright, 1992 use both indices), "Human development index" (Kleinknecht et al, 2002) and "Ratio of researchers in R&D" (Nelson and Wright, 1992). Most indices are quite ad-hoc and new indicators may emerge as defining the notion of leadership and technology advances. It could be that AI may change the whole notion of leadership. But as for today, the list we presented is a good description of the various indices which exist in the literature. Table B2 presents the various variables susceptible of being a good index for leadership in technology, and Table B3 shows the correlation between these various indices.

2.2 A Short History of Human Capital and Higher education

Human capital was not considered a key driver of economic growth until around 1870, and it is therefore not surprising that the major economic book published in 1867, analyzing society at the time, was entitled *Das Kapital* rather than *Das Human Kapital*. For centuries, capital, alongside land and labor, were the main factor of production. However, things changed from the 1870s onward: with the impact of the industrial revolutions, there was a growing need for workers to become educated. Schooling therefore became a necessity in the West; compulsory schooling was introduced in England in 1880, and in some other countries in the years that followed.[2]

However, higher education institutions were not central to the industrial revolutions and technological change. For a long time, universities were part of the religious establishment, and their main role was to teach liberal arts, philosophy, and theology, although some became renowned for specific subjects, such as law in Bologna and medicine in Montpellier. Most university students, whose numbers were in any case small, were preparing for careers in the Church, even after the Reformation.

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2 In the case of France and Sweden, in 1882.

Then, in the nineteenth and early twentieth centuries, universities underwent reform; they generally became secular, and they started to teach new subjects, particularly the sciences. Still, a university degree was not necessary for a career but for some few specific professions.

During the last half of the twentieth century, a dramatic change took place in higher education: The number of universities and colleges in the West rose, and the number of students increased even more. Concurrently with this democratization of higher education, universities became heterogeneous not only in their specializations, but in their quality.

Based on these facts, a literature emerged on the impact of human capital and higher education. The first line of thought was the human capital theory, which focuses on the effects of investment in education on the economy as well as on the individual. The main precursors are Schultz (1961), Becker (1964), and Mincer (1974), who is well known for the "Mincer equation."

The second line of research on education is the signaling theory, developed initially by Spence (1973) and further by Arrow (1973) and Stiglitz (1975). This theory argues that individuals use education as a "signal" of their value. For a signal to be credible, it must be costly to obtain, so that high-ability individuals find it less costly to acquire education than low-ability individuals.

These two theories are not mutually exclusive, and this paper combines both within the model: human capital theory captures differences in academic standards, while signaling theory relates to differences across universities in the selectivity of student admissions. Indeed, these two dimensions are the main drivers of polarization in higher education.

2.3 A Short History of Polarization in Higher education

As we have underlined above, the development of higher education systems has taken place, after World War II, and has followed rather diverse orientations in advanced economies. Let us highlight key facts in the history of polarization.

The first is the democratization of tertiary education, with admission procedures based on meritocracy. In many advanced countries, this democratization has come with the development of a two-tier system characterised by the concomitance of standard and elite universities. This differentiation between two types of universities has widened over time since the huge increase in the number of students has primarily concerned standard universities, the selection remaining narrow in elite establishments. The two differences emphasized by the literature, as well as this paper, are the differences in level of academic standards and in the selectivity of students.

A. Polarization in the level of academic standards

A substantial empirical literature shows that education and human capital are far from homogenous. Hanushek and Woessmann (2008, 2012) and Barro (2013) stress that cognitive skills and the quality of schooling matter more for economic growth than sheer educational attainment. Similarly, Altinok and Aydemir (2016) establish that the impact of school quality on growth varies

across regions and development levels. Brezis and Crouzet (2006) show that differences in university quality can lead countries to adopt different types of new technologies, ultimately shaping growth trajectories.

A second fact related to polarization in academic standards is that standard and elite universities differ in their budgets, which largely determine their quality. The expenditures per student are substantially higher in elite universities than in standard ones, and this gap has increased in the last decades in a number of advanced countries.

In the US, expenditures per student in elite universities (Ivy League) are more than three times higher than in other universities. In addition, from 1999 to 2009, these expenditures increased by 20% in elite universities, and by less than 8% in standard ones (Desrochers and Wellman, 2011). In France in 2002, the spending per student is on average 3.5 times higher in the top GE than in standard universities.[3]

The polarization in academic standards affect employment in public sector, and also research. Temin, (1999), for the US; and Baverez, (1998}, for France have shown that entering an elite university is the natural path to the highest private and public positions. Moreover, Azoulay et al. (2011) show that star scientists in elite institutions drive the diffusion of new knowledge, highlighting the central role polarization in academic standard play in technological leadership.

B. Polarization in the Selectivity of students

Polarization in higher education stems from the fact that individuals differ in their innate capabilities, and various measures seek to capture this heterogeneity. The heterogeneity of skills can be assessed through standardized tests like SAT scores, which measure potential before students enter higher education.[4]

About polarization of enrolment in the US, Su et al. (2012) note that, between 1959 and 2008, the non-elitist public post-secondary colleges have increased their enrolment by 525% against 250% in elite colleges. In France, elite universities are represented by the *Grandes écoles*, GE that recruit less than 4% of a generation. Albouy and Wanecq (2003) have shown that there was almost no change in the recruitment of the top *Grandes écoles*, while at the same time the share of a generation completing tertiary education was multiplied by more than 3.5.[5] In contrast, Nordic countries do not exhibit such differences in the selection processes across universities.[6]

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[3] Data from the *Observatoire Boivigny*.

[4] The literature highlights not only skills and ability, but also family background. It also points to potential biases in meritocratic examinations (see Brezis & Hellier, 2018; Hellier, 2025). This paper assumes that such bias, while it can have a large effect on stratification, has only a small effect on signaling. Moreover, family background can generate substantial stratification effects, but it does not create bias in the signaling equilibrium.

[5] They define the '*Très Grandes écoles*', GE as the most prestigious schools leading to the highest top executive and public positions. They show that, for men, the share of a generation entering these top GE decreased from 0.8 for the generations born between 1929 and 1938, to 0.6% for those born between 1959 and 1968.

[6] The variance between elite and standard universities is much lower in Denmark, Finland and Norway (Brezis, 2012).

The literature has also focused on the fact that the access to elite universities is mostly open to the elite's offspring, the stratification effect. In the US, SAT scores are highly correlated with family education and wealth (Brezis and Temin, 2008; Carnavale and Strohl, 2010). Carnevale and Strohl (2010) show that the top socioeconomic quartile represents 70% of the students in the most selective colleges, against 14% for the bottom half of the population, this difference having significantly increased from 1982 to 2006.

For France, Albouy and Wanecq (2003) show that, since the end of World War II, the difference in the probability to enter a *Grande école* between students from the upper class and the 'popular classes' has followed a U-curve.[7] These facts clearly indicate that that there is social stratification in the access to elite universities, and that the social segregation and stratification in the entry to elite establishments has increased in the last decades. [8]

Related to social mobility in the US, Chetty et al. (2020), show that access to top colleges is highly unequal yet strongly linked to upward mobility. This aligns with Piketty's (2014) broader argument that unequal access to elite education and human capital perpetuates wage gaps over the long run. Indeed, he identifies the unequal distribution of education and skills as the fundamental driver of long-term wage inequality.

Moreover, Brezis and Hellier (2018) show that a dual higher-education system, characterized by the coexistence of standard and elite universities, generates enduring social stratification and limited upward mobility. Kerckhoff (1995) argues that the effect of family background is amplified in stratified and selective education systems, an argument confirmed by studies such as Hanushek and Woessmann (2006), Pfeffer (2008), and Dronkers et al. (2011).

In conclusion, the topic of polarization in higher education is stimulating, and this paper contributes to this growing line of inquiry. The literature we have summarized sets the stage for the model presented in the next section, which highlights how the polarization gaps in both academic standard and selectivity of students, shape technological leadership and inequality. The model we now present is novel, by relating polarization in higher education to the dichotomy between high-tech and low-tech sectors.

III. The model

This model analyzes the effects of polarization in higher education on leadership in technology and inequality. This model will show that technological leadership, T_L and inequality, I_N are a positive function of the two elements of the polarization in higher education, P_1 and P_2. In the

[7] The upper-class offspring were 27 times more likely to enter a GE than those from the popular classes in the generations born in1929-1938 , 17 for the 1949-1958 generations, and 20 for the 1959-1968 generations.

[8] As emphasized in footnote 4, family background is a major driver of stratification. In our model, family background is incorporated into individuals' "capability." We do not distinguish between innate abilities and acquired abilities prior to university entry.

following sections, we define all these variables, and more specifically the meaning of polarization in higher education, denoted as P_1 and P_2.

The assumption of polarization in higher education is not commonly used in models of technological leadership, and it is the specificity of this model.[9] Indeed, as underlined in Brezis and Crouzet, (2006), during the last half of the twentieth century, a dramatic change took place in higher education: The number of universities and colleges in the West rose, and the number of students increased even more. Concurrently with this democratization of higher education, universities became heterogeneous not only in their specializations, but in their academic quality and standard.

When higher education is provided only to very few, there is no need for selection, and universities may not differ in their quality and prestige. Yet, when higher education is democratized and nearly 50% of the population attends colleges or universities, uniformity in their quality is usually not kept. There is, therefore, a distinction between on the one hand, the elite universities, for which after World War II, selection became meritocratic, and on the other hand, the others.[10]

In consequence, students with high capability will through meritocratic exams enter elite universities, so that in countries with polarization in higher education, there is a 'Spence separating equilibrium'. Moreover, we show that the high-tech sector can pay more for the productivity of students from elite schools, due to the knowledge received in top universities, so that polarization leads to a separating equilibrium also in the production sector. Students from elite universities go to work in the high-tech sector. We then get, inequality in wages as well as leadership in technology.

We start the presentation of the model by defining the output sector, the higher education sector and then the labor sector. We then turn to analyze leadership in technology and inequality. The model is mainly based on the theories of human capital and signaling, which were presented in the literature section.

3.1 The Demand and supply of goods

There are two types of goods in the economy, high-tech goods, Y_T and traditional, low-tech goods, Y_{NT}. We assume an elasticity of substitution of 1 between these goods, so the utility function will take a Cobb-Douglas form such as:

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[9] See for instance, Acemoglu and Autor (2011); Autor and Dorn (2013), and all seminal papers in this field by Acemoglu, Aghion, Autor, Dorn et al.

[10] There are several published rankings of universities, so that their ranking is public knowledge. This paper emphasizes that the large number of students and universities contributes to the divide in quality, creating a dichotomy between elite and standard institutions. (This phenomenon is not limited to higher education; it is also existing in the realm of academic journals. However, this paper focuses exclusively on the polarization within higher education).

$$U(Y_T, Y_{NT}) = Y_T^{\pi/(1+\pi)} Y_{NT}^{1/(1+\pi)}, \quad (1)$$

π is the ratio of the demand of high-tech over low-tech goods.

These two goods, Y_T and Y_{NT} uses three factors of production: labor, capital and human capital; respectively L, H and K. The output function can take many forms. For sake of simplicity, we assume a CES function between H and L, so that skilled and unskilled workers are substitute factors of production, and we assume that workers (skilled and unskilled), and capital K have a constant rate of substitution of 1. These assumptions are quite common and can be found in the literature on wage premium (see for instance Autor and Dorn, 2013).

In this model, we assume that human capital, H is not *homogenous*: we have in fact two different types of human capital, H_E for workers graduating from elite universities; and H_{NE} for workers graduating from standard universities. The two types of human capital are perfect substitute, and the producer can hire either workers graduating from elite universities or from standard universities. This is the main assumption of this paper, and it differs from most models in the literature. In consequence the production functions of the non-tech, and the tech goods take the following forms:

$$Y_{NT} = K^{1-\beta}[(a_1 H_{NE} + a_2 H_E)^{\alpha} + (a_u L)^{\alpha}]^{\frac{\beta}{\alpha}}. \quad (2)$$

and

$$Y_T = K^{1-\beta}[(a_1 H_{NE} + E a_2 H_E)^{\alpha} + (a_u L)^{\alpha}]^{\frac{\beta}{\alpha}} \quad (3)$$

where β and α are between 0 and 1, and E>1. The respective costs of the factor of productions of L, H_{NE}, H_E and K are: W_u, W_S^l, W_S^h, and *r*. For sake of simplicity, we take a similar ratio in both goods, β and even assume a same substitution rate between skilled and unskilled labor, α.

We define a_1 as the productivity of H_{NE}, which equals the capability of the skilled workers having acquired higher education in standard universities; a_2 is the productivity of H_E, which equals the capability of the skilled workers having acquired higher education in elite universities, and a_u as the productivity of non-skilled workers, L.

E is the externality effect of top education on the high-tech sector. Indeed, the productivity of the workers in high-tech sector, having graduated from an elite university and having received education at the frontier of knowledge has a higher effect than if they would have graduated from a standard university. The main element which affects this externality in productivity, *E* is the gap in academic standard and quality in universities, which are affected by the level of budgets of the universities.

In consequence, this externality of elite education, *E* is affected by budgets, B invested in labs and scholars. Students from elite universities are therefore more productive in the high-tech sector, since budgets, invested in elite universities are higher. This externality due to gap in budgets is one of the elements of polarization in higher education, as we show in the next section.

3.2 The Labor sector

We assume that individuals have different capabilities.[11] We could assume that personal capability is continuous and is randomly distributed across individuals. However, we may assume a simpler assumption, since in Brezis and Hellier (2018), we show that for all capabilities lower than a, students would be accepted in standard universities, and for capability higher than a, they will be accepted in elite universities. Therefore, for sake of simplicity, we regroup all the capabilities lower than a, and denote then by a_l (**w**hich denote the average of all capabilities lower than a). For capabilities higher than a, we regroup them and denote it by a_h, (which could be the average of all capabilities higher than a). So, capabilities are either high denoted by a_h, or low denoted a_l. For sake of simplicity, we assume that:

$$a_h = \delta a_l \qquad \text{where } \delta > 1. \tag{4}$$

This difference in capability of individuals affects the economy through two channels. First, smarter people learn more rapidly, and therefore for getting the same grade or diploma, they have to invest less effort than an individual with low capability. In consequence, capability affects their results on entry exams to universities (based on signaling theory). We return to this channel in the next section.

The second channel is through the labor market. The productivity of each human capital H is a function of the average ability of the skilled workers having acquired this type of education: a_1 and a_2 for non-elites and elite education respectively. So, if only high ability individuals graduate from an elite university, we get $a_2 = a_h$. If only low capability individuals graduate from elite universities, we get $a_2 = a_l$, but if there are equal amount of low ability and high ability graduates from elite universities then $a_2 = (a_l + a_h)/2$.

3.3 Polarization and The Higher Education sector.

The structure of higher education systems varies greatly across OECD countries. As highlighted by Brezis and Crouzet (2006) and Brezis and Hellier (2018), the second half of the twentieth century brought dramatic changes to higher education: in many countries, the number of universities and enrolled students grew significantly (see the literature section).

[11] An individual's capability is influenced by three components: ability at birth, effort invested in learning during youth, and family background.

However, as higher education has become more accessible, and the number of institutions has increased, academic standards have not remained uniform across all institutions. some universities maintain higher standards than others. This pattern is not universal, though, while some OECD countries have highly polarized systems, others remain far more homogeneous. This variance allows us, in the empirical part of this paper, to construct an index of polarization and analyze its consequences. Since countries differ in the extent of polarization within their higher education systems, we can analyze its impact on technological leadership and inequality.

In countries, where polarization exists, we get that there are elite universities, in which when graduating, the student acquires a human capital of type H_E; and there are standard universities, in which the student acquires human capital of type H_{NE}.

There are entry exams to the different universities, and the grades on the entry exam to the elite universities, are much higher than the grades to enter standard universities.[12] In consequence, we get the following polarization: Students with high grades on their entry exam will get access to elite universities and acquire human capital of type H_E. Students with lower grades (but with a high school diploma) register to a standard university and acquire human capital of type H_{NE}. Finally, individuals who did not graduate from high school will stay unskilled, and display a factor of production, L.

The main differences between elite and standard universities are (i) academic standard and quality, which are affected by budgets, and (ii) the selectivity of student admissions. These two elements define the polarization gap. The first dimension of polarization gap, denoted P_1 is the difference in academic standard and quality, and is a function of the gap in budgets.

$$P_1 = P_1(B_E / B_{NE}) \quad \text{while} \quad E = \psi P_1(B_E / B_{NE}) \qquad (5)$$

where B_E and B_{NE} are budgets in elite and standard universities respectively.

The second polarization gap, P_2 represents the selectivity of student admissions**:**

$$P_2 = \frac{H_{NE}}{H_E} \qquad (6)$$

A higher P_1 due to large budgets in elite universities leads to an increase in the externality E; A higher P_2 means that the selectivity in elite universities has increased. We show in the next section that these two polarization elements affect positively technological leadership and inequality.

[12] In the various countries, the exam is slightly different. In the US, it is SAT, in France the "prep exams". See the literature section, and Brezis and Crouzet (2006) for more details.

3.4 Leadership in technology and Inequality.

In the literature, there are many possible definitions of leadership in technology. In this research, following Fernando and Fabien, (2016), we focus on the relative production of sectors, so that technological leadership, T_L is defined as:

$$T_L \equiv \frac{Y_T}{Y_{NT}} \tag{7}$$

This paper also analyzes inequality, I_N which is defined as the ratio of wages of skilled works educated in top universities, vs. standard ones:

$$I_N \equiv \frac{W_S^h}{W_S^l} \tag{8}$$

where W_S^h are the wages of skilled workers graduating from elite universities, and W_S^l the wages of those graduating from standard universities. In the next section, we show that in fact, this ratio is the ratio of skilled workers with high capabilities versus low capabilities. Indeed, we show that workers with high capability have graduated from elite universities, while the others from standard universities.

3.5 The Equilibrium.

The model defined by equations (1)-(4) can give place to a large number of solutions and equilibria, depending upon which type of students enter which type of universities. However, there is one equilibrium which is simple to analyze and is the adaption of the "Spence separating equilibrium" to our analysis.

Indeed, under the conditions that costs of learning are neither too high (so that high ability individuals will have the incentives to invest in acquiring education in elite universities), nor too low (to avoid that low ability students will also invest in acquiring education in elite universities), we obtain that the separating equilibrium is stable and no individual has incentives to deviate from this solution. So, following Brezis and Brand (2018), we can show that under conditions on the gap in the costs of education, the gap in the average capability, and the relative size of the sectors, we get a "Spence separating equilibrium', so that low capability individuals graduate from standard universities and go to work in the non-tech sector, while high capability workers, will graduate from elite universities, and work in the high-tech sector. This separating equilibrium allows us to derive the following lemma:

Lemma

Under conditions that costs of learning are neither too high, nor too low and on relative demand of goods, individuals with high capability, will graduate from a top university, will get human capital H_E, and will work in the high-tech sector. Individuals with low capability, will get human capital H_{NE}, and will work in the low-tech sector. [13]

This lemma claims that the workers are separated in where they work. Moreover, since the skilled workers in the tech sector are of high capability and have acquired human capital of type H_E, we then get that $a_2 = a_h$, and skilled workers in the non-tech sector are with low capability, have received education H_{NE} and we get that $a_1 = a_l$.

In consequence, the production functions (2)-(3) take the following forms:

$$Y_T = K^{1-\beta}[(Ea_h H_E)^{\alpha} + a_u L^{\alpha}]^{\frac{\beta}{\alpha}} \qquad (9)$$

$$Y_{NT} = K^{1-\beta}[(a_l H_{NE})^{\alpha} + a_u L^{\alpha}]^{\frac{\beta}{\alpha}} \qquad (10)$$

Let us now analyze the effect of polarization on leadership and inequality

Proposition of the Model

Technological leadership, T_L and wage inequality, I_N are a positive function of the two elements of the polarization in higher education, P_1 and P_2.

Proof

Let us start with wage inequality, defined by: $I_N \equiv \frac{W_S^h}{W_S^l}$

In order to calculate I_N, let us calculate the ratio of wages of workers, R_T and R_{NT}. Recall that the wages: W_S^l, W_S^h, W_u are equal to the value of marginal products of H_E, H_{NE} and L respectively. Assuming that price of Y_{NT} is 1, and the price of Y_T will add one more variable in ψ, so we ignore it for sake of simplicity. From equation (9), we get:

$$W_u = \frac{\partial Y_T}{\partial L} = \beta K^{1-\beta} L^{\beta-1} a_u{}^{\alpha}[(Ea_h \frac{H_E}{L})^{\alpha} + (a_u)^{\rho}]^{\frac{\beta-\alpha}{\alpha}}. \qquad (11)$$

and:

[13] For a rigorous proof of the lemma and the Spence signaling equilibrium, see Brezis and Brand (2018).

$$W_S^h = \frac{\partial Y_T}{\partial H_E} = \beta K^{1-\beta} {H_E}^{\beta-1} (Ea_h)^{\alpha} [(Ea_h)^{\alpha} + (a_u \frac{L}{H_E})^{\alpha}]^{\frac{\beta-\alpha}{\alpha}} . \quad (12)$$

So

$$R_T = \frac{W_S^h}{W_u} = (\frac{Ea_h}{a_u})^{\alpha} (\frac{H_E}{L})^{\alpha-1} . \quad (13)$$

From the non-tech production function, equation (10), we get:

$$W_u = \frac{\partial Y_{NT}}{\partial L} = \beta K^{1-\beta} L^{\beta-1} {a_u}^{\alpha} [(a_l \frac{H_{NE}}{L})^{\alpha} + (a_u)^{\alpha}]^{\frac{\beta-\alpha}{\alpha}} . \quad (14)$$

$$W_S^l = \frac{\partial Y_{NT}}{\partial H_{NE}} = \beta K^{1-\beta} {H_{NE}}^{\beta-1} {a_l}^{\alpha} [(a_l)^{\alpha} + (a_u \frac{L}{H_{NE}})^{\alpha}]^{\frac{\beta-\alpha}{\alpha}} . \quad (15)$$

and the ratio is:

$$R_{NT} = \frac{W_S^l}{W_u} = (\frac{a_l}{a_u})^{\alpha} (\frac{L}{H_{NE}})^{1-\alpha} \quad (16)$$

So we get I_N :

$$I_N = \frac{W_S^h}{W_S^l} = \frac{R_T}{R_{NT}} = (\frac{Ea_h}{a_l})^{\alpha} (\frac{H_{NE}}{H_E})^{1-\alpha} = \psi P_1^{\alpha} \delta^{\alpha} P_2^{1-\alpha} \quad (17)$$

About technological leadership, $T_L \equiv \frac{Y_T}{Y_{NT}}$, in a similar way, we get

$$T_L = \frac{Y_T}{Y_{NT}} = \beta E^{\alpha} \delta^{\alpha} (\frac{H_{NE}}{H_E})^{1-\alpha} = \Omega \beta P_1^{\alpha} \delta^{\alpha} P_2^{1-\alpha} \quad (18)$$

This model has shown that technological leadership, T_L and wage inequality, I_N are a function of the two elements affecting the polarization gap: the gap in academic standard and quality, P_1 and the gap in selectivity of students admission, P_2. A third element affecting technological

leadership and inequality is the gap in capability among individuals, δ. In conclusion, an increase in both elements of polarization (academic standard and selectivity of student admissions) lead to higher leadership and inequality.

We now turn to the main task of the paper: empirical analysis. In the next section, we develop indices of polarization and technological leadership, and we check the relationship between the various variables.

IV. Empirical Analysis

This paper examines the relationship between polarization in higher education, technological leadership, and inequality. The empirical analysis is divided into two main parts. First, we develop novel indices to measure these concepts; second, we perform an econometric analysis to test the core equations of the theoretical model (equations (17) and (18)).

Since no established indices for higher education polarization exist in the literature, we construct original measures for this purpose. We also create a new index for technological leadership. The empirical work then tests how these indices interact, focusing on whether polarization in higher education is associated with greater technological leadership and higher inequality.

Our analysis begins by developing a polarization index that captures the two main differences between elite and standard universities. The first dimension measures the gap in budgets, which reflects differences in academic standards and educational quality. The second dimension assesses how selective elite universities are compared to standard ones, using data on student admissions criteria. We start by detailing the construction of the index for the polarization gap in academic standards.

This empirical analysis focuses on OECD countries, which broadly represent the advanced economies. Among the OECD's 38 members, we concentrate on the 17 most advanced economies, those at the frontier of technological leadership. Data collection was challenging, and given the novelty of this research, we view this sample as an appropriate starting point.[14]

4.1 Polarization gap in academic standard and quality

There are significant differences in the budget per student between elite and standard universities. This budget disparity directly affects the level of academic standards, as emphasized

[14] Further research should extend the sample to additional countries. For example, South Korea, although an OECD member, is not included because we encountered difficulties in obtaining reliable data; China should also be incorporated, despite not being an OECD member. It would also be useful to examine whether countries with little or no technological leadership nonetheless display polarization in higher education, and to identify the factors associated with inequality in those settings, since it would presumably not be driven by educational quality or by technological knowledge and advances. These extensions, however, are beyond the scope of this paper.

by Desrochers and Wellman (2011). Institutions with larger budgets can invest more in faculty, research facilities, and student support, which in turn enhances educational quality and research output.[15]

The index of the polarization gap in quality is presented in Table 1, column 1. In each country, we identify the top universities based on the Shanghai ranking (ARWU) and calculate the budget per student for these top institutions.[16] The polarization gap index for academic standard is the ratio of the budget per student at top universities to the average budget per student (The indicator was standardized on a common scale, with the United States receiving a score of 100, and the scores of other countries were determined accordingly).

Here are some concrete examples. In England, the budget per student at the top three universities, including Cambridge, is $80,400, which is 3.12 times the national average of $25,770 per student (79.19 on the standard scale). In the United States, the top three universities, including Stanford, have a budget per student of $111,500, while the national average is $28,300—3.94 times the average budget (100 on the scale).[17]

The index presented in Table 1, col. 1 shows that countries with a high polarization index are the US, France, the UK, as well as Israel and Japan. (The index takes the value of 100 for the US; 30.46 for Sweden and 43.91 for Finland).

4.2 Polarization gap in selectivity of student admissions

The aim of the index is to check the difference in the admissions selectivity between the prestigious universities and the standard ones. The way the index is calculated is the following: A priori, we should check the admissions selectivity at the level of a university, but because of the absence of information on admission scores, at the level of the entire academic institution for most countries, we gather data on specific subjects of study. We focus on the most in-demand fields of study in the countries in our sample, which are Economics, Psychology, Computer Science, and Law, over the 2023–24 academic years.[18]

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15 See Desrochers and Wellman. 2011.

16 There are many university rankings. However, the Shanghai Ranking is among the best known, and it focuses on research quality, not only on teaching. Moreover, we checked alternative rankings, and the differences in results were small.

17 For Sweden, Uppsala University has a budget per student of $28,000 compared to $23,300 for the average budget. So, it is only 1.2 times the average budget (30.46). And to give one more example, for Finland, University of Helsinki has a budget of $30,960, compared to $17.90 average budget, so that we have a polarization index of 1.73 (43.91).

18 How should we choose the fields to include in the index? Because our goal is to capture selectivity, we focus on fields in which admission is genuinely competitive—i.e., where not all applicants are accepted. In other words, we select disciplines characterized by "excess demand." This approach is used for most countries in our sample. For the United States, there is more extensive information and therefore it was possible to perform calculations at the level of the university. Information can be found on the government website https://nces.ed.gov.

In the next step, using the Shanghai ranking, we check the universities which are ranked high in those subjects of study and those which are ranked low. For all of these universities and subjects, we checked the required admission score.

The polarization index is calculated as the ratio in the admission selectivity between the highest ranked one, and the median one.[19] In each country, and each university we focus on, we check the lowest grade needed to be accepted at the university. Given the distribution of students' grades on exams, we can calculate the percentage of students who are accepted from the population of students. We denote this percentage as the admissions selectivity in this specific university (The indicator was standardized on a common scale, with the United States receiving a score of 100, and the scores of other countries were determined accordingly).

Let us present some examples. In the US, Harvard University is ranked first in the Shanghai ranking. The percentage of applicants who are admitted is 5%, so the admissions selectivity at Harvard is 5%. In average in the US higher education system, we get that 28 % of all applicants are accepted. The calculation of the polarization index for admissions selectivity for the US is then 5.6 (28 divided by 5) and 100 on the standard scale. The data is presented in Appendix 1.[20]

Table 1, column 2 presents the polarization index of the admissions selectivity. In countries with a high level of inequality, such as US, Israel, and the UK, the polarization index is high (100 for US, 68.78 for Israel, and 79.19 for UK) and in countries with a low level of inequality the polarization index is also low, such as Denmark (19.64) and Sweden (25). This is the only research we know, which is presenting this index.

It is interesting to note that the index based on budgets (and academic standard), P_1 , and the index based on admissions selectivity, P_2 , are strongly correlated (R-squared= 0.5371, p-value= 0.002).

4.3 The Leadership Index

In the theoretical model, leadership in technology is defined as the relative productivity between sectors. What would be a good index to reflect this relative productivity? In the literature, many indices were presented (see section 2.1). A comprehensive index of national technological leadership should ideally incorporate multiple dimensions of leadership.

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[19] We could also compare a university that is not ranked to the highest ranked one, but this index will not have a similar comparison in the various countries.

[20] In the UK, the top university is Cambridge. The average score of acceptance is such that only 13.8% of applicants are admitted (average of the four fields of study). In the median-ranked University of Fribourg, the university admits 49.2% of applicants. In consequence, the index of the recruitment gap in the UK is 3.6. (49.2/13.8), 79.19 on the standard scale. In Denmark, the applicant at the University of Copenhagen (ranked first) has a 56% chance of admission compared to a 61% chance for the median-ranked university, Aalborg University. Thus, Denmark's index is 1.1 (61/56), 19.64 on standard scale, significantly lower than the US or UK.

Furthermore, the index should be relatively simple to implement and rely on readily available, high-quality data.

Two particularly significant indicators of technological leadership are research and development (R&D) expenditure as a percentage of GDP and patents per capita. R&D expenditure directly measures a nation's investment in innovation, while patents provide a tangible metric for productivity of the leading sectors. By combining these two indicators into a composite index, we can gain a more nuanced understanding of a nation's technological leadership. This is the leadership index we have chosen.

To construct the index, we obtained raw data on R&D expenditure as a percentage of GDP and the number of patent applications per capita. These two parameters were then normalized to a common scale, with the United States serving as the benchmark (assigned a score of 100), and other countries receiving scores relative to the US. The final index was calculated as the average of these two normalized indices.

Table B1 in the appendix presents the two components of the calculated index (R&D and patents) as well as the final composite index, which is the average of the two. The leadership index is presented in column 3 of Table B1 and in Table 1, column 4.

In section 2.1 of the related literature, we have shown that there are other possible indices. These alternative indices are presented in Table B2. We investigated the correlation between all these indices. Table B3 presents the correlations among these various indices, as well as their correlations with the polarization indices and the Gini index.

4.4 Econometric Analysis

To test the empirical relevance of the theoretical model, we estimate the relationship between higher education polarization and both technological leadership and wage inequality across countries. Correlations are presented visually in Figures 1-2.

The analysis uses cross-sectional data for 17 OECD countries, drawing on the polarization indices developed in this paper.

$$Y_i = \alpha + \beta_1 * \text{GapQuality}_i + \beta_2 * \text{GapSelectivity}_i + X_i'\gamma + \varepsilon_i$$

where Y_i represents either the Leadership Index or the Gini coefficient for country i. The key explanatory variables are the two polarization measures: the gap in academic standards (proxied by the budget per student in elite vs. standard universities) and the gap in selectivity of student admissions.

We also estimate alternative specifications including standard controls, such as GDP per capita and the share of tertiary graduates, to account for differences in economic development and

human capital levels that could otherwise blur the relationship. Given the relatively small sample size, the results should be interpreted cautiously.

4.5 Results

Empirical Regularity 1: This paper examines the effects of the polarization indices in higher education, P_1 and P_2, on the Technological leadership index, T_L.

Table C1 reports the estimates for the Leadership Index. Both the gap in academic standards and the gap in selectivity are positively and significantly associated with technological leadership. The magnitude of the coefficients suggests that countries with more polarized higher education systems -- in both dimensions -- tend to score higher on measures of innovation and frontier technology. This finding is consistent with the model's prediction that polarization channels high-capability students into elite universities, which in turn fosters technological leadership.

Empirical Regularity 2: This paper examines the effects of the polarization indices in higher education, P_1 and P_2, on wage inequality, I_N.

Table C2 presents the results for the Gini coefficient. Here again, both polarization measures are positively and significantly related to income inequality. This reflects the model's mechanism whereby greater sorting and stratification in higher education amplify wage disparities among skilled workers.

While the results are robust to including basic controls, they should be interpreted with caution due to the cross-sectional design and the novel nature of the polarization indices. Nonetheless, these findings offer new empirical support for the trade-off highlighted in this paper: countries aiming to be at the technological frontier may need to accept a more polarized higher education system, which inevitably generates higher inequality.[21]

V. Conclusion

This paper focuses on the effects of polarization in higher education on technological leadership and inequality. It shows that a nation implementing a public education policy that establishes polarization between top-tier and standard universities may stimulate technological progress and leadership, but at the cost of greater inequality. Specifically, countries characterized by a large polarization gap tend to achieve leadership in science and engineering technologies, where the 'polarization gap' measures the distinctions between elite and non-elite universities.

[21] This is a novel line of research; consequently, the data are still limited, and we therefore rely only on OLS estimates. Over time, we plan to expand the dataset by adding more years and more countries, which will make the empirical analysis more robust and allow us to use panel methods and more sophisticated econometric tests.

The initial finding of this paper is that the polarization gap contributes to higher productivity and inequality by directing top workers toward sectors where high ability significantly influences productivity. In countries with a high polarization gap, a distinction arises among students, resulting in a separating equilibrium. This means that only students with high capabilities graduate from top universities, while skilled workers with lower capabilities are admitted to standard universities. Conversely, in countries with low polarization, there is no separating equilibrium, and no alignment occurs between students' capabilities and the universities they attend.

In this paper, the primary distinction between high-tech and low-tech sectors lies in the positive externality between education type, worker capability, and the nature of goods produced. In the high-tech sector, the productivity of workers educated at the forefront of knowledge is higher than if they had graduated from a standard university.

Top universities, by being at the cutting edge of knowledge, play a crucial role. Directing the best students toward sectors that can best exploit this advanced knowledge fosters technological progress. In countries with a high polarization gap, clear differentiation among students ensures that elite universities impart this knowledge to those most capable of applying it in sectors with rapid technological change, such as high-tech industries.

In consequence, countries choosing to develop dual quality education tracks can reach the frontier of leadership in technology but at the price of higher inequality, while countries without this polarization in higher education will not be at the frontier of knowledge. The choice of the high education policy affects productivity growth.

Another aspect developed in this model is the link between technological leadership and inequality among workers. This paper argues that inequality is the price of being at the frontier of technology and experiencing rapid productivity gains. Brezis and Hellier (2018) further show that these two elements of polarization, academic standards and selectivity, also reduce social mobility and increase stratification.

In the empirical section, we compile new data on both the Leadership Index and the Polarization Index, which consists of two components: an academic standard gap (proxied by the gap in budgets) and a selectivity gap. The results show that, in OECD countries, there is a correlation between technological leadership, inequality, and the degree of polarization in higher education.

A country that primarily adopts existing technologies without pushing the technological frontier may avoid significant heterogeneity in its higher education system and, consequently, wage inequality. However, a nation aiming to lead in knowledge and innovation must establish elite universities where admission is based on meritocratic exams, which inevitably leads to increased inequality.

An interesting case for future research could be China, which is not an OECD country and is not included in our sample. In China, much of the inequality does not stem from the capital-labor divide, as most capital is state-owned. Nonetheless, inequality is high and continues to rise, largely due to inequality among skilled workers, which is precisely the focus of this paper.

Indeed, China's higher education system is strongly shaped by its entrance exam to universities, the *gaokao*, suggesting a high polarization index. Moreover, the type of inequality discussed in this research has sharply increased in China over the past decade.

In recent years, China has made significant technological advances, producing a large volume of highly cited research and substantial investments in high-tech industries. Therefore, the relationship this paper highlights between inequality, leadership, and polarization in higher education is not only relevant for OECD countries but also for any nation seeking to lead in fields that drive economic growth.

In conclusion, it is clear that future research should expand the sample to include a larger set of countries. On the theoretical side, an important next step is to confront the challenge posed by AI for the polarization of higher education. The direction in which higher education is moving is far from clear. If anything, polarization may become even more significant in the age of AI, because the rationale for teaching at lower levels is weakened when AI can perform many routine cognitive tasks more effectively. In that world, polarization is not a side effect; it becomes the organizing principle.

It is possible that the institutions most likely to endure will be those that do what AI cannot easily replicate: cultivate judgment, train creativity, and generate new knowledge. The central constraint may therefore shift from a production of skills in general to the production of frontier talent, knowledge, and skills. These questions are worth research, however, lie beyond the scope of this paper.

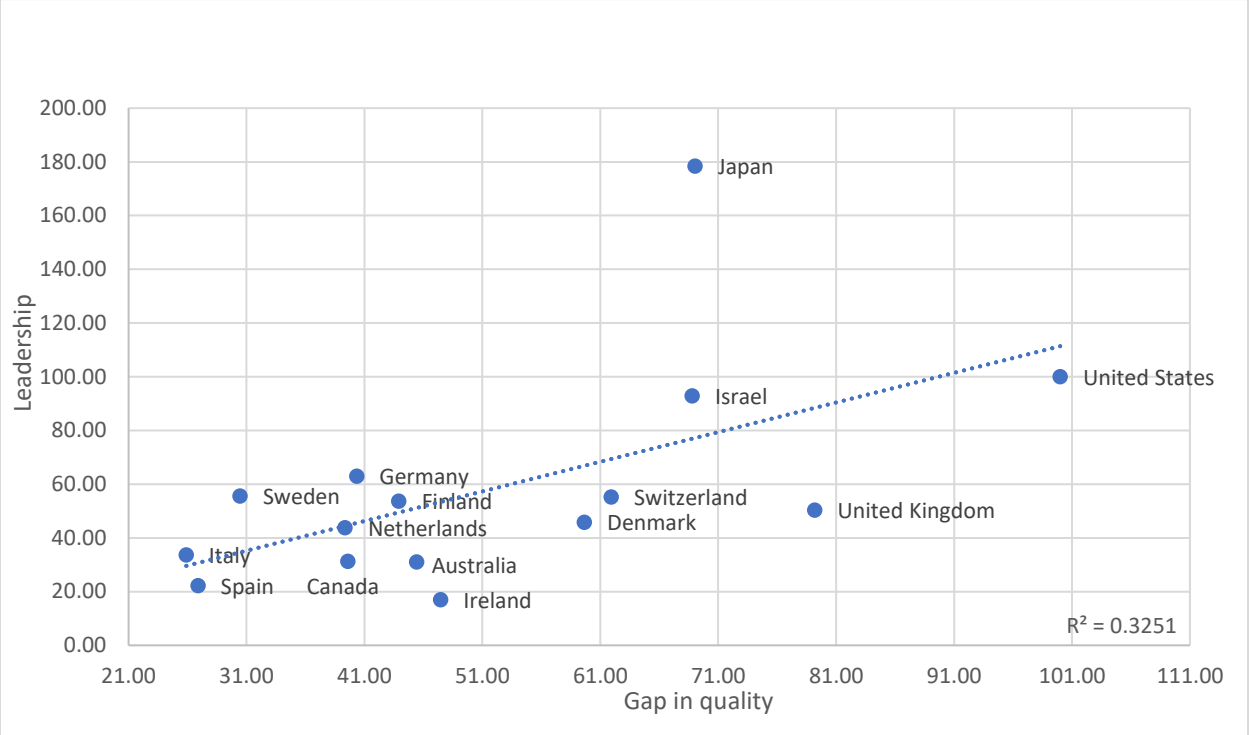
Table 1: Indices on the polarization Gap, Inequality, and Leadership in Technology.

	P_1 (1)	P_2 (2)	Gini index (3)	Leadership Index (4)
Australia	45.43	50.00	48.93	31.05
Canada	39.59	50.00	49.35	31.21
Denmark	59.64	19.64	43.40	45.81
Finland	43.91	28.57	43.33	53.71
France	-	57.14*	45.11	55.94
Germany	40.36	46.43	46.94	62.97
Ireland	47.46	53.57*	48.62	16.94
Israel	68.78	69.64	59.66	92.83
Italy	25.89	33.93*	50.39	33.70
Japan	69.04	89.29	53.77	178.46
Netherlands	39.34	35.71	42.48	43.77
Norway	-	28.57	40.17	35.94
Spain	26.90	28.57	46.01	22.22
Sweden	30.46	25.00	40.68	55.59
Switzerland	61.93	25.00	42.21	55.18
UK	79.19	64.29	46.94	50.37
United States	100.0	100.0	58.31	100.0

Sources: World Bank, World Forum, and own calculations.

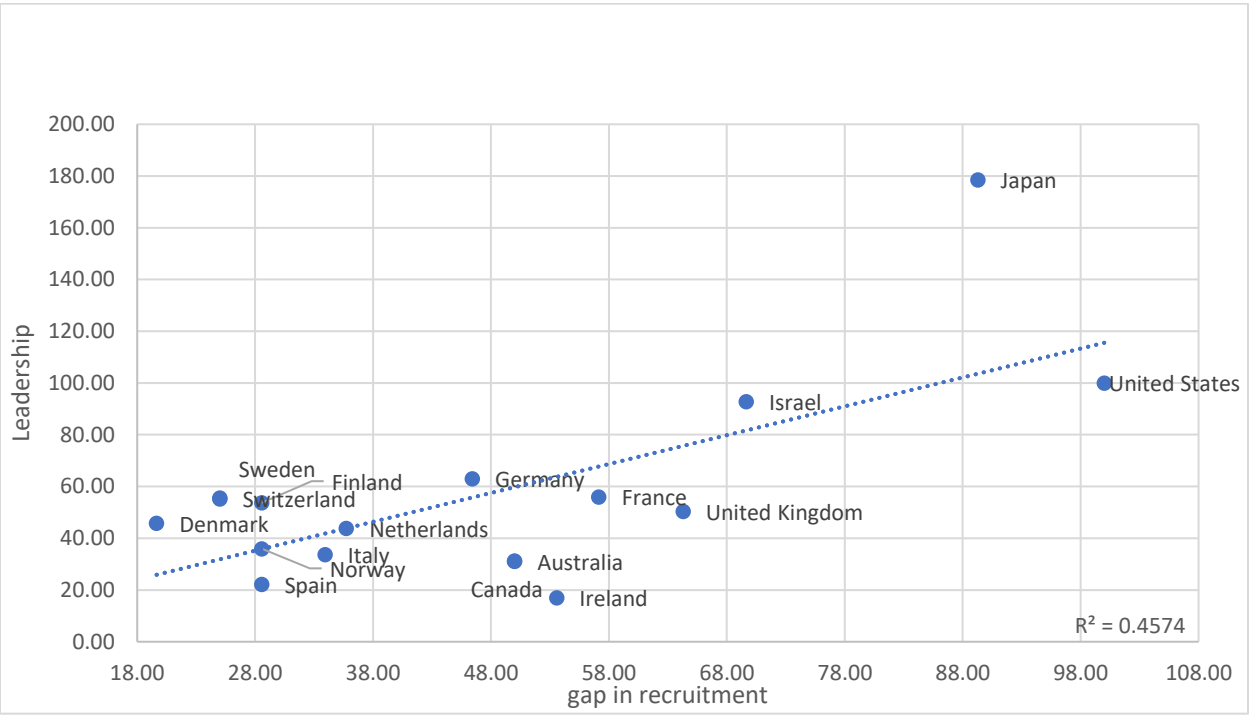
Notes: column (1) is the index of polarization gap in academic standard and quality as explained in section 4.1; column (2) is the index of polarization gap in selectivity of student admissions as explained in section 4.2 and elaborated in appendix 1; Column (3) is the Gini index of disposable income before taxes; Column (4) is the index of leadership, as presented in the appendix Table B1, column (3).

Figure 1: Technological leadership index, T_L and P_1, the gap in quality



Source: own calculations

Figure 2: Technological leadership index, T_L and P_2, the gap in selectivity of recruitment



Source: own calculations

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APPENDICES

Appendix 1. The polarization gap index in student recruitment

Table A1: The gap in admission scores of students in top and median universities

country	Local Rank	Law	Computer Science	Psychology	Economics	Average
Australia	First- The University of Melbourne	8	14	12	10	11
	Median- Deakin University	26	46	29	23	31
	First vs median	**3.2**	**3.3**	**2.4**	**2.3**	**2.8**
Canada	First- University of Toronto	10	8	15	7	10
	Median- Carleton University	20	15	40	40	29
	First vs median	**2**	**1.9**	**2.7**	**5.7**	**2.9**
Denmark	First- University of Copenhagen	31	90	14	88	56
	Median- Aalborg University	49	90	17	88	61
	First vs median	**1.6**	**1.0**	**1.2**	**1.0**	**1.1**
Finland	First- University of Helsinki	5	10	13	5	8
	Median- University of Turku	15	10	15	13	13
	First vs median	**3**	**1**	**1.2**	**2.6**	**1.6**
Germany	First- Heidelberg University	4	4	4	5	4.3
	Median-Martin Luther University Halle-Wittenberg	8	14	9	14	11.3
	First vs median	**2**	**3.5**	**2.2**	**2.8**	**2.6**
Israel	First- The Hebrew University of Jerusalem	3	2	6	11	5.5
	Median- Ariel University. For law: Reichman University	6	10	38	32	21.5
	First vs median	**2**	**5**	**6.3**	**2.9**	**3.9**
Japan	First- The University of Tokyo	1	5	13	5	6
	Median- Miyazaki University For law: Ehime University, for psychology: Ochanomizu University *	30	30	20	40	30
	First vs median	**30**	**6**	**1.5**	**8**	**5**
Netherlands	First- University of Amsterdam	10	10	8	5	8.3
	Median- University of Groningen	20	15	10	20	16.3
	First vs median	**2**	**1.5**	**1.25**	**4**	**2.0**
Norway	First- University of Oslo	1	5	1	9	11.5
	Median- University of Stavanger. for CS and psychology: OsloMet - the metropolitan university	11	15	15	35	19.0
	First vs median	**11**	**3.0**	**15**	**3.9**	**1.6**
Spain	First- University of Barcelona*	45	45	40	60	48
	Median- University of La Laguna. for CS: first- Complutense University of Madrid, median- University of Las Palmas de Gran Canaria.	75	90	50	90	76
	First vs median	**1.7**	**2**	**1.2**	**1.5**	**1.6**

country	Local Rank	Law	Computer Science	Psychology	Economics	Average
Sweden	First- Lund University	4	8	4	20	9
	Median- University of Gothenburg	7	20	4	20	12.7
	First vs median	**1.7**	**2.5**	**1**	**1**	**1.4**
Switzerland	First- University of Zurich	8	8	13	13	10.5
	Median- University of Fribourg	15	15	15	15	15.0
	First vs median	**1.9**	**1.9**	**1.2**	**1.2**	**1.4**
UK	First- University of Cambridge	15	10	20	10	13.8
	Median- University of Fribourg	56	47	47	47	49.2
	First vs median	**3.7**	**4.7**	**2.4**	**4.7**	**3.6**
US	First- Harvard University					5
	average					28
	First vs average					**5.6**

Notes:

We present data for the four most relevant fields we examined. We checked the required admission score.
There are differences between countries in the admission methods and grades required.
Some countries require "normalized" external tests (such as the SAT or ACT in the US), other countries require external tests in selected subjects (such as the "A level" in the UK).
There are countries where the average grades in high school are enough (such as Sweden) and there are countries that combine different indicators (such as Israel which combines the "Psychometric" test with scores from the matriculation exams) In order to be able to compare the countries and the different admission methods, the scores were converted into a uniform bar, in percentages.

Appendix 2. The Leadership Index- Tables B1-B3

Table B1: The Construction of the Leadership Index

Country Name	R&D/GDP (1)	Patents/population (2)	Leadership Index (3)
Australia	52.9	9.2	31.05
Canada	49.1	13.3	31.21
Denmark	81.4	10.3	45.81
Finland	86.5	21.0	53.71
France	64.2	47.7	55.94
Germany	90.9	35.0	62.97
Ireland	32.7	1.2	16.94
Israel	160.7	24.9	92.83
Italy	42.1	25.4	33.7
Japan	95.3	261.6	178.46
Netherlands	66.8	20.8	43.77
Norway	56.1	15.8	35.94
Portugal	48.6	4.0	26.29
Spain	41.3	3.1	22.22
Sweden	98.9	12.3	55.59
Switzerland	97.2	13.2	55.18
United Kingdom	84.3	16.4	50.37
United States	100	100.0	100.0

Source: Data from the World Bank website were standardized to an index, where the US was assigned a score of 100 and the scores of the other countries were adjusted accordingly.
Note: Column (3) = (column (1) + column (2))/2.

Table B2: The various indices of technological leadership in the literature

Country Name	Leadership Index (1)	High-tech exports/ total exports (%) (2)	Ratio of Researchers in R&D / population (per million) (3)	Human Development Index (HDI) (4)	Tertiary graduates (%) (5)	patent/ pop. (6)	R&D / GDP (%) (7)	The Global Innovation Index (8)	high R&D industries/"Business economy" (%) (9)
Australia	31.05	40.690	4532.40	0.951	20	4	1.829	55.22	
Canada	31.21	17.850	4516.30	0.936	26	6	1.697	55.73	1.99
Switzerland	55.18	28.841	5551.97	0.962	24	6	3.359	68.30	11.54
Germany	62.97	26.523	5393.15	0.942	35	15	3.142	57.05	3.59
Denmark	45.81	25.608	7691.89	0.948	20	5	2.813	57.70	4.43
Spain	22.22	23.609	3109.24	0.905	20	1	1.429	49.07	1.95
Finland	53.71	21.834	7527.36	0.940	28	9	2.989	59.97	3.82
France	55.94	20.756	4926.19	0.903	20	21	2.219	53.59	4.67
UK	50.37	20.554	4683.77	0.929	25	7	2.915	62.42	2.78
Ireland	16.94	16.830	4769.14	0.945	28	1	1.131	59.13	8.25
Israel	92.83	15.991	-	0.919	23	11	5.557	53.54	7.92
Italy	33.7	15.805	2671.83	0.895	21	11	1.454	46.40	2.48
Japan	178.46	13.670	5454.68	0.925	18	115	3.296	53.97	3.17
Netherlands	43.77	13.370	5911.68	0.941	17	9	2.309	61.58	3.85
Norway	35.94	12.415	6698.84	0.961	16	7	1.938	53.80	1.49
Sweden	55.59	8.770	7930.81	0.947	19	5	3.417	62.40	4.43
United States	100.0	8.132	4821.23	0.921	24	44	3.457	60.10	4.08

Source: OECD, United Nations, World bank and own calculations.
Notes: Column (1) is the leadership index presented in Table B1, column III. See section 2.1 for the sources of the indices.

Table B3: Pearson correlation coefficient between the various indices

	Gini Index	high R&D industries/ total "Business economy"	global innovation index	Gap in quality	Gap in recruitment	High-tech exports/ total exports (%)	Ratio of Researchers in R&D / population (per million)	Human Development Index (HDI)	Tertiary graduate (%)	patent/ population (per 100 k)	R&D/GDP (%)	leadership index
Gini Index	1											
high R&D industries/ total "Business economy"	0.07	1										
global innovation index	-0.32	0.53	1									
Gap in quality	0.54	0.24	0.37	1								
Gap in recruitment	0.82	-0.01	-0.06	0.73	1							
High-tech exports/ total exports (%)	-0.17	0.28	0.02	-0.17	-0.28	1						
Ratio of Researchers in R&D / population (per million)	-0.55	0.13	0.53	0.09	-0.32	-0.15	1					
Human Development Index (HDI)	-0.49	0.31	0.65	0.05	-0.35	0.23	0.65	1				
Tertiary graduates (%)	0.18	0.22	0.23	0.05	0.12	0.23	-0.09	0.07	1			
patent/population (per 100 k)	0.45	-0.14	-0.13	0.43	0.67	-0.30	-0.02	-0.23	-0.18	1		
R&D/GDP (%)	0.39	0.39	0.32	0.54	0.33	-0.18	0.56	0.05	0.11	0.26	1	
leadership index	0.52	0.04	0.03	0.57	0.68	-0.32	0.15	-0.16	-0.10	0.92	0.62	1

Source: own calculations.

Appendix 3. Econometric Results

Table C1: Impact of Higher Education Polarization on Technological Leadership

Variable	(1) Leadership Index	(2) Leadership Index	(3) Leadership Index
Gap in Academic Standards	0.45 ** (0.18)	0.38 ** (0.17)	0.32 ** (0.15)
Gap in Selectivity	0.52 ** (0.21)	0.47 ** (0.20)	0.40 * (0.22)
GDP per capita		0.15 (0.12)	0.14 (0.11)
Share of Tertiary Graduates			-0.10 (0.09)
Constant	2.10 *** (0.35)	1.95 *** (0.40)	1.85 *** (0.38)
Observations	17	17	17
R^2	0.42	0.48	0.52

Notes: Robust standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table C2: Impact of Higher Education Polarization on Inequality

Variable	(1) Gini Coefficient	(2) Gini Coefficient	(3) Gini Coefficient
Gap in Academic Standards	0.30 ** (0.12)	0.28 ** (0.11)	0.25 ** (0.10)
Gap in Selectivity	0.35 ** (0.14)	0.32 ** (0.13)	0.29 ** (0.13)
GDP per capita		0.07 (0.05)	0.06 (0.05)
Share of Tertiary Graduates			-0.04 (0.03)
Constant	25.5 *** (2.1)	24.0 *** (2.2)	23.5 *** (2.3)
Observations	17	17	17
R^2	0.38	0.42	0.47

Notes: Robust standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.