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A Story of Strengths and Weaknesses in Tertiary Education: Evaluating 'Mobility' and 'Opportunities' in OECD Countries with Composite Indicators

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Abstract: Assuming a high education level associated with a high probability of job occupancy and greater income, comparative exercises analyzing academic performances and socioeconomic dynamics at regional, country, or supra-national scales have intensified in recent years. As far as tertiary education is concerned, a great disparity in academic performance was characteristic of OECD countries. While adults 25–34 years old were attaining tertiary degrees more frequently than adults 55–64 years old, adults 30–34 years old with at least one tertiary-educated parent were more likely to attain a tertiary degree than individuals from families whose parents have attended secondary—or at least primary—education. 'Mobility' and 'opportunities' are two dimensions of sustainable education systems that deserve further investigation when assessing disparities in academic performances as a possible source of unsustainable development and social polarizations. 'Mobility' refers to the probability of achieving tertiary education for children coming from families with a different—i.e., lower (e.g., secondary or primary)—level of education. 'Opportunities' refers to the probability for a child to attain tertiary education, regardless of the education level achieved by the parents. The present study proposes a quantitative assessment of both dimensions through an original approach and novel statistical measures ranking OECD countries. A comparison of individual rankings of 'mobility' and 'opportunities' reveals counterintuitive results in some cases. To overcome this issue, our study introduces aggregate methods combining the two measures with the aim of developing a bivariate ranking that accounts for both dimensions simultaneously and delineates a more complete evolution of academic performance divides in advanced economies.

Keywords: education; mobility; opportunities; socioeconomic dynamics; advanced economies

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1. Introduction

Education performance and socioeconomic outcomes are closely related; higher education levels are associated with improved health and higher incomes when entering the job market [1–3]. However, levels of educational achievement are demonstrated to be handed down among generations [4]. Children living in families with university-educated parents obtain the same title more frequently than those from families with parents that have lower educational qualifications [5–7]. In OECD countries, parents' educational attainment was demonstrated to be a stronger predictor of children's education attainment than, e.g., age or gender [8–10]. Moreover, educational attainment is correlated across generations, implying that educational traits persist over time [11–13]. Nevertheless, the share of individuals with at least one university-educated parent in total population varies significantly across countries [14]. For instance, Italy and Turkey showed a particularly low share (5% and 4%, respectively); from the opposite side of the ranking, particularly high shares were observed in Israel (43%), Canada (42%), and New Zealand (42%). Low upward mobility, however, does not necessarily indicate a lower opportunity to attain a high education level [15]; upward mobility may be low in countries where a considerable share of parents has already attained tertiary education [16–19]. To evaluate how a family's educational level matters for a given individual in achieving the highest educational title, 26 countries (Australia, Austria, Canada, Chile, Denmark, Estonia, Finland, France, Germany, Japan, Greece, Ireland, Israel, Italy, Korea, Norway, New Zealand, Holland, Poland, Czech Republic, Slovakia, Slovenia, Spain, United States, Sweden, and Turkey) were investigated considering aggregate (country-level) data for individuals 30–44 years old from OECD [14]. Based on the mainstream literature [20], original measures separately assessing 'mobility' and 'opportunities' were introduced here.

The contribution of education issues to a broader sustainable development path at local, regional, and country scales is clearly documented in the most recent strategy of Agenda 2030, based on 17 Sustainable Developmental Goals (SDGs). In this perspective, education is at the heart of the 2030 Agenda for Sustainable Development, being identified as a stand-alone target for policy intervention (Goal 4), and is also present as targets under other SDGs on health, growth and employment, sustainable consumption and production, and climate change. Ensuring equity, inclusion, and gender equality is one of the intrinsic objectives of any policy referring to SDG 4. It specifically focuses on effective learning and the acquisition of relevant knowledge and competencies-in terms of vocational and technical skills for decent work as well as for global citizenship in a plural and interconnected world.

In this perspective, 'mobility' and 'opportunities' are the two basic dimensions of a sustainable (tertiary level) education system, whose interaction may deserve further investigation, especially when investigating disparities in academic performance as a possible source of unsustainable development and social polarizations [21–28]. More specifically, 'mobility' reflects the probability of achieving tertiary education for children coming from families with a different—i.e., lower (e.g., primary or secondary)—level of education [29]. 'Opportunities' deal with the probability for a child to attain tertiary education, regardless of the education level achieved by the parents [19]. The former dimension is quantified with an index elaborating the difference in probability of achieving tertiary education between children from families characterized with heterogeneous levels of education (12, 2019). The latter dimension evaluates the probability for a child to achieve tertiary education regardless of the level of education achieved by the parents [17]. OECD countries were initially ranked according to the two indexes separately (e.g., [30]). Since the two indexes may capture different aspects of the same phenomenon [10], we developed a new index that addresses the two dimensions simultaneously, as a contribution to the policy target "ensuring equity, inclusion and gender equality" intrinsically referring to SDG 4 (see above).

Based on these premises, our paper was organized as follows. Section 2 presents OECD survey data and introduces the basic notations and definitions adopted here, in turn providing a brief review of recent literature on composite indicators in social science, with a specific focus on education attainment. This section also delineates an original methodology aggregating 'mobility' and 'opportunities' indexes into a composite indicator. Section 3 describes the results of the individual indexes of 'mobility' and 'opportunities', discussing the desired properties and the relevance for policy matters. Section 4 illustrates the corresponding ranking for each OECD country, a brief methodological comparison among the different approaches adopted here, and a specific analysis of the empirical relationship between the composite indicator and expenditure on tertiary education. Section 5 concludes the paper.

2. Methodology

2.1. Data

We used country-level data for 26 countries, namely Australia, Austria, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Poland, Slovak Republic, Slovenia, Spain, Sweden, Turkey, and the United States. Data were derived from the Survey of Adult Skills under the OECD Programme for International Assessment of Adult Competencies (PIAAC) [14]. Focusing on individuals 30–44 years old, the following percent shares (in total population 30–44 years old) were calculated: (i) adults that have attained tertiary education and whose parents both have less than tertiary education; (ii) adults attaining tertiary education and who have at least one parent that attained tertiary education; (iii) adults whose parents both have no more than secondary education level; and (iv) adults who have at least one parent achieving a tertiary education degree [31]. Data on expenditure on educational institutions as a percentage of Gross Domestic Product (GDP) for different levels of education (with a focus on tertiary education) were finally derived from OECD official statistics.

2.2. Basic Definitions and Notation

We summarized information on the education achievements of parents and children through a 2 × 2 (correspondence) matrix, denoted with E. The rows of the matrix indicate the education level of the parents, whereas the columns represent the same variable for the children. In particular, PL denotes the event 'to have at least one parent tertiary-educated'; $\overline{PL}$, the complement of PL, represents the event 'to have neither parent tertiary-educated'; CL denotes the event 'to have achieved tertiary education', and $\overline{CL}$ indicates the complement of CL, the event 'to have not achieved tertiary education'. Consequently, the columns display the percentage of children that have achieved tertiary education (CL) or not ($\overline{CL}$). Likewise, the rows indicate the percentage of parents (at least one) that have achieved tertiary education (PL) or not ($\overline{PL}$). We use p to denote the percentage of children who have not achieved a tertiary education level, given that their parents have not achieved the tertiary education level, $p = P(\overline{CL}|\overline{PL})$. In the same way, q represents the probability that a child has not achieved a tertiary education level given that he/she has at least one parent that has achieved a tertiary education level, $q = P(\overline{CL}|PL)$. Formally:

$$E = \begin{pmatrix} P(\overline{CL}|\overline{PL}) & 1 - P(\overline{CL}|\overline{PL}) \\ P(\overline{CL}|PL) & 1 - P(\overline{CL}|PL) \end{pmatrix} = \begin{pmatrix} p & 1-p \\ q & 1-q \end{pmatrix} \quad (1)$$

This specification can be interpreted as a sort of transition matrix, and the rows sum to one. In fact, we observe that this is a particular case of an $n \times n$ transition matrix with $n = 2$. Thus, starting from the definition of intergenerational mobility reported in [8], we assume two groups (parents and children) stratified according to their level of education, which consist of two states ('with tertiary education' and 'without tertiary education'). Again, the parents' status is reported by rows, and the columns denote the children's status. Based on these premises, the correspondence matrix can be interpreted as an intergenerational transition matrix since we are analyzing the educational status of parents (at time t − 1) and children (at time t).

'Mobility' and 'Opportunities': Two Sides of the Same Coin?

We assumed intergenerational mobility to be strongly related with income levels, and we thus divided the income distribution of both parents and children into n quantiles. Moreover, here we do not require the matrix E to be bi-stocastic; that is, both rows and columns sum to one, since a row-stochastic matrix completely satisfies such a key assumption. The following example clarifies our definition. The matrix calculated for Italy is:

$$E_{ITA} = \begin{pmatrix} e_{1,1} & e_{1,2} \\ e_{2,1} & e_{2,2} \end{pmatrix} = \begin{pmatrix} 86.1\% & 13.9\% \\ 32.3\% & 67.7\% \end{pmatrix} \quad (2)$$

The upper left value (86.1%) indicates the percentage of adults not achieving tertiary education from families where no parents have achieved tertiary education. This means that the remaining 13.9% has achieved tertiary education. Likewise, the bottom row represents the percentage of adults from families where at least one parent has achieved tertiary education, where 32.3% of children have not achieved tertiary education and the remaining 67.7% have. Since the numbers in each row sum to one, E is a row-stochastic matrix.

Looking at q distribution, we find that the observed values range from 20.7% to 57.1%. Half of countries are concentrated in the interval (30–40%); Poland, Korea, and Israel have the lowest values—20.7%, 21.0%, and 21.3%, respectively. This means that only 20% of children whose parents have tertiary education do not achieve tertiary education; the remaining 80% graduate. Austria (57.1%), Sweden (44.2%), and Estonia (40.0%) rank bottom. Figure 1 compares p and q values for all OECD countries, outlining a moderate correlation ($\rho = 0.47$) between these two dimensions. Countries with the percentage of individuals whose educational status does not change with respect to their parents are on the diagonal. Without loss of generality, we assume $p > q$. Empirical data confirm this assumption, since the mean of p and q was 0.69 and 0.30, respectively; p and q ranged between 0.497 and 0.878 and between 0.207 and 0.571, respectively, meaning that the majorization holds.

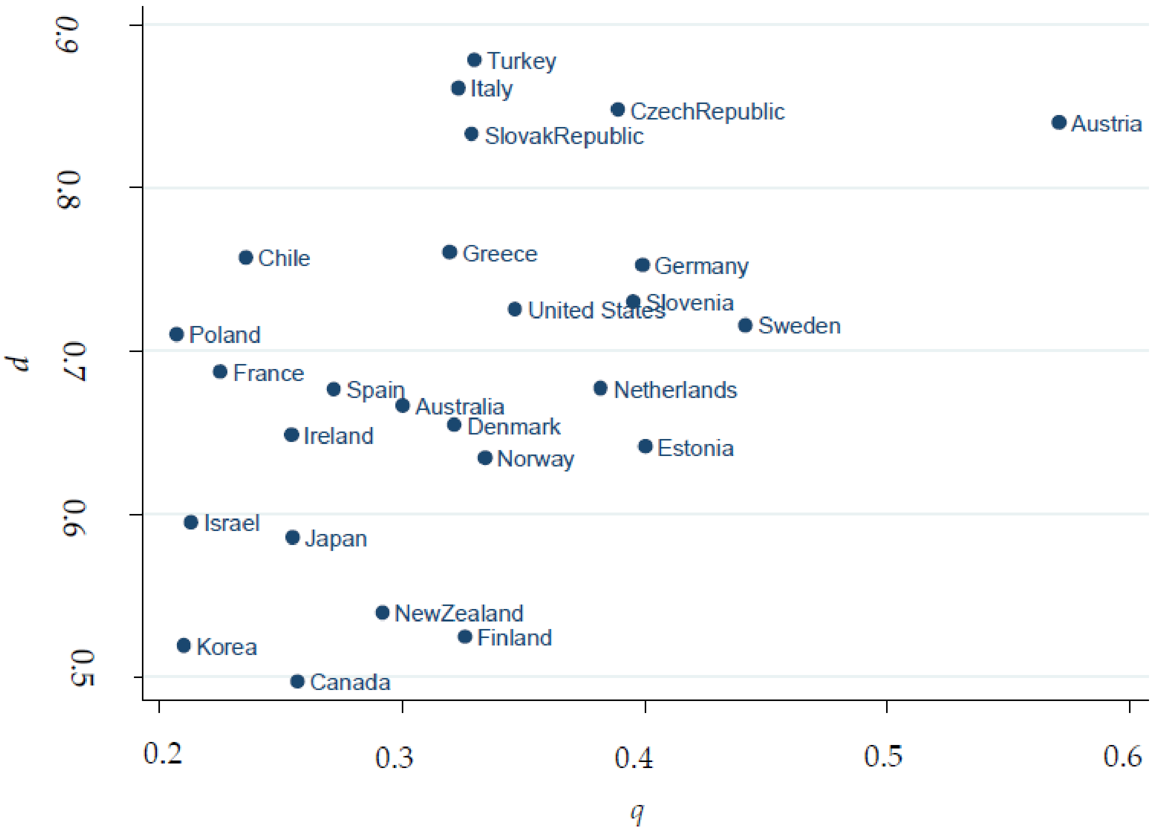

Figure 1. The relationship between 'p' and 'q' dimensions in OECD countries (see text for explanation). Source: own elaboration on OECD data.

2.3. Statistical Analysis

2.3.1. Discrimination Index

We define a Discrimination Index (Δ) associated with the matrix E as the difference in the probability of achieving tertiary education for children from families with different levels of education. Formally, we have:

$$\Delta = \Pr(CL|PL) - \Pr(CL|\overline{PL}) = (1-q) - (1-p) = p - q \quad (3)$$

Having set $p > q$, Δ is strictly positive. A value of Δ approaching zero means that parents' education does not determine the educational achievement of their children. In other words, parents' educational levels have no effect on the child's educational level, reflecting a condition of 'perfect mobility'. When the index reaches zero ($p = q$), we have null discrimination among the children coming from families with low or high educational levels. Positive values of Δ delineate societies in which children are more likely to graduate if at least one parent is a university graduate. The highest discrimination is achieved when the transition matrix coincides with the identity matrix; that is, $p = 1 - q = 1$. In this case, we have no intergenerational transition between educational levels.

2.3.2. Mobility Index

Literature on mobility has introduced several measures based on the transition matrix. The construction of such indices enables appropriate geographical comparisons, since countries can be ranked according to the computed indices. Assuming that there are n different classes (or states) in a given country, the transition matrix P is an $n \times n$ matrix and $p_{ij}, i, j = 1, \ldots, n$ denotes a generic element representing the probability that a child with a parent whose income falls in quantile i ends up with an income in quantile j [8]. Assuming such conditions, Shorroks [32] defined two indices capturing mobility: the trace index (T) and the determinant measure (D), namely

$$T = \frac{n - Tr(P)}{n-1} \qquad D = 1 - \frac{det(P)}{n-1}, \quad (4)$$

where $Tr(P)$ and $\det(P)$ denote, respectively, the trace and the determinant of the transition matrix P. Assuming the highest values clustered along the main diagonal, T is a concentration measure characteristic of a given transition matrix. Similarly, Conlisk and Sommers [33] introduce an index based on the eigenvalues of the transition matrix, defined as

$$\Lambda = 1 - \lambda \quad (5)$$

where λ denotes the second largest eigenvalue of P, while the first is equal to one following the properties of the transition matrix. For $n = 2$, the transition matrix P reduces to the matrix E defined above. Thus, in particular situations with two states, T, D, and Λ reduce to the same value:

$$T = D = \Lambda = 1 - (p - q). \quad (6)$$

Moreover, the above-mentioned indices are closely related to Δ since

$$T = D = \Lambda = 1 - \Delta. \quad (7)$$

Δ can therefore be interpreted as a 'persistency index' outlining a stable education status across generations. In other words, the lowest discrimination, which in turn corresponds to the highest mobility, is achieved if all rows of the transition matrix are identical. In this way, discrimination can be interpreted as the reverse of mobility. Consequently, since we expect that the greater the value, the better the situation, we compute the complement to 1 of the discrimination index. With this transformation—the sole effect of which is to overturn the ordering induced by the index—higher values correspond to better situations.

Thus, the greater the value of Δ, the lower the social mobility will be. We denote the new index as

$$MI = 1 - \Delta. \tag{8}$$

2.3.3. Opportunities Index

To formulate an index estimating the inherent 'opportunities' in tertiary education, we introduce the parameter k, i.e., the probability for a child to have both parents without a tertiary degree. That is,

$$k = Pr\ (\overline{PL}) \tag{9}$$

and, consequently,

$$1 - k = 1 - \Pr(\overline{PL}) = \Pr\ (PL) \tag{10}$$

represents the probability that a child came from a family in which at least one parent has a tertiary education level. We combine the information contained in p, q, and k to define the 'opportunity' index. The probability that a child does not attain tertiary education independent of the education level of the parents is given by

$$P(\overline{CL}) = kp + (1 - k)q \tag{11}$$

Based on this definition, the opportunity index, *OI*, is the complement to 1 of the probability that a child does not attain tertiary education and ranges from 0 to 1, equalling zero ($OI = 0$) in the 'worst case' and one ($OI = 1$) in the best case, as follows:

$$OI = 1 - P(\overline{CL}) = 1 - kp + (1 - k)q \tag{12}$$

2.3.4. Index Properties

Following [32], we introduce properties that might be satisfied by an index that simultaneously accounts for discrimination and mobility. We remember that the index should be a continuous real function, denoted by *I* and defined over the set of (transition) matrices *E*. We restrict the range of the index to the interval [0,1] for easier comparison. Thus, we introduce a set of axioms describing index properties:

Axiom 1. *[Normalization] (N):* $0 \leq I(E) \leq 1$.

This is a common requirement for all indices. It does not impose significant constraints on the set of potential measures, while rescaling the values of the index itself. According to the classical measure of mobility, the probability of movement between classes is given by the off-diagonal elements of the transition matrix. Here, we have $1 - p$ and q, which represent the movements between classes; that is, the transition from a parent without tertiary education to a child with tertiary education (element e_{12}) and from a parent with tertiary education to a child without tertiary education (element e_{21}). A second requirement is that the index should increase if there is an increase in the off-diagonal elements at the expense of the diagonal elements, which indicates 'persistency', namely the fact that people remain in the same status between generations. Thus, we compare two situations denoted by means of two matrices, E and E'. We assume that $E \geq E'$ if $p_{ij} \geq p'_{ij}$ for all $i \neq j$ and $p_{ij} > p'_{ij}$ for some all $i \neq j$. Formally:

Axiom 2. *[Monotonicity] (M):* $E \geq E'$ *implies that* $I(E) \geq I(E')$.

Moreover, we define an index that accounts for two extreme situations, that is, the index assumes a zero value in the worst case and a unity value in the best case.

Axiom 3. *[Worst case] (W):* $I(E) = 0$.

Axiom 4. *[Best case] (B):* $I(E) = 1$.

Axiom 3 implies that E has identical rows while Axiom 4 ensures that the index is one when matrix E coincides with the identity matrix. Proof that the 'mobility' index introduced above satisfies these properties can be easily derived from the considerations presented above.

2.4. Composing Individual Indexes into a Summary Indicator

Literature on composite indicators related to social, economic, and environmental domains consolidated in the last decades [34] and will develop further thanks to the rising availability of digital data in any research field [35]. Multivariate indicators collapsing information into a single metric attracted increasing attention in recent times [36], likely because they allow the performance of a given unit (e.g., country or region) to be measured (and compared) over time and space in a fast and intuitive way [37]. Instead of multiple measures, a single number contributes to both political decisions and public communication [38]. Although collapsing a multivariate set of information into a single number might hide some interesting aspects [39], advantages largely overpass disadvantages in this kind of aggregation. Conceptually speaking, the idea behind the aggregation of the two indexes in a single measure was aimed at delineating a latent dimension of long-term sustainability in tertiary education [40]. In other words, we assumed the outcomes of tertiary education in a given economic system as sustainable (sensu [41]) if the two dimensions of 'mobility' and 'opportunities' reach the highest scores [42], i.e., giving the best chance to achieve a satisfactory education level in the most favorable socioeconomic context to a given student [43]. The highest ranks of the composite indicator thus delineate a condition of long-term sustainability of the tertiary education system [44], in turn reflecting the intrinsic efficiency of the system itself [45].

With this perspective in mind, we investigated the appropriateness of different methodologies aggregating the two elementary indexes introduced above into a composite index: (i) the arithmetic mean (EW), (ii) the Adjusted Mazziotta-Pareto index (AMPI), and (iii–vii) five modifications thereof based on distinctive weighting systems that depend on the Gini coefficient, its reciprocal value (GW, iG, GAMPI, and iGAMPI), and the geometric mean (GM). Ciommi et al. [46] provided a detailed description of these methodologies. We represent our data with a matrix X, whose entry x_{ij} represents the value of the j-th elementary indicator corresponding to the *i*-th country, with *j* = 1, 2, and *i* = 1, 2, …, 26. As proven by [46], the following formula summarizes six methods for building the composite indicator for a given country *i*

$$C_i = \left(\frac{1}{\sum_{j=1}^{2} (G_{.j})^{\alpha}} \cdot \sum_{j=1}^{2} r_{ij} \cdot \left(G_{.j}\right)^{\alpha} \right) - \beta \cdot (S_i \cdot cv_i) \tag{13}$$

where $\alpha = \{-1,0,1\}$, $\beta = \{0,1\}$, and

$$r_{ij} = \frac{x_{ij} - \underline{x}_{j}}{\overline{x}_{.j} - \underline{x}_{j}} \cdot 60 + 70 \tag{14}$$

denotes the normalized indicators obtained according to the Mazziotta and Pareto method [47] (it covers the interval [70,130]); $\underline{x}_j = Rif_{.j} - \left(Max_{.j} - Min_{.j}\right)/2$ and $\overline{x}_{.j} = Rif_{.j} + \left(Max_{.j} - Min_{.j}\right)/2$ are the two *goalposts* for MI and OI, respectively. $Max_{.j}$ and $Min_{.j}$ are the respective maximum and minimum values of the two indicators (denoted by j) across all OECD countries, whereas $Rif_{.j}$ denotes the reference value; that is, the average value for any indicator. $G_{.j}$ represents the Gini index computed for indicator j across all countries. Finally, S_i and cv_i denote, respectively, the standard deviation and coefficient of variation of all normalized indicators r_{ij}. The six indices were determined choosing different combinations of α and β. The simplest index, EW, is obtained by fixing $\alpha = 0$ and $\beta = 0$. The resulting index is

$$C_i^{EW} = \frac{1}{2}\sum_{j=1}^{2} r_{ij} \tag{15}$$

which represents the simple mean. With the simple mean, we assume that the two indexes, namely MI and OI, have the same weight and thus the same importance. This is a reasonable requirement when we have no a priori information about the relative importance of the characteristic dimensions of the phenomenon under investigation. The second method is the Adjusted Mazziotta–Pareto method [13], hereafter $AMPI$, computed as C_i by assuming $\alpha = 0$ and $\beta = 1$. Thus, for a given country i we have

$$C_i^{AMPI} = \left(\frac{1}{2} \cdot \sum_{j=1}^{2} r_{ij}\right) - S_i \cdot cv_i \tag{16}$$

As stressed by Mazziotta and Pareto, this method belongs to non-compensatory composite measures based on a penalty function ($S_i \cdot cv_i$). The starting point for constructing the $AMPI$ is the computation of the arithmetic mean of the elementary indexes, adjusting for horizontal variability of the indexes themselves. The third method, GW, captures vertical inequality. It is a modification of the EW method where, instead of choosing the same weight for both indicators, we compute a weighted average of MI and OI with weights based on the Gini index of inequality. With this system of weights, we account for the distribution of indicators [48]. Formally, we have

$$C_i^{GW} = \frac{1}{\sum_{j=1}^{2} G_{.j}} \cdot \sum_{j=1}^{2} r_{ij} \cdot G_{.j} \tag{17}$$

GW weights unequal distributions more heavily [49], so if we believe that a more homogenous distribution of an indicator should imply a higher weight for that indicator, we use the inverse Gini index as the weighting system. Thus, the definition of the iGW index is as follows:

$$C_i^{iGW} = \frac{1}{\sum_{j=1}^{2} (G_{.j})^{-1}} \cdot \sum_{j=1}^{2} r_{ij} \cdot \left(G_{.j}\right)^{\alpha} \tag{18}$$

The fifth and sixth methods are a combination of GW, $AMPI$, iGW, and $GAMPI$, respectively. In detail, for the former, the starting point is GW, penalized as in the $AMPI$ method. The resulting method is the so-called $GAMPI$, defined as

$$C_i^{GAMPI} = \left(\frac{1}{\sum_{j=1}^{2} G_{.j}} \cdot \sum_{j=1}^{2} r_{ij} \cdot G_{.j}\right) - S_i \cdot cv_i \tag{19}$$

whereas, for the former, $iGAMPI$, the starting point is the iGW, which we penalize according to the $AMPI$ method. The resulting index is computed as follows:

$$C_i^{iGAMPI} = \left(\frac{1}{\sum_{j=1}^{2} (G_{.j})^{-1}} \cdot \sum_{j=1}^{2} r_{ij} \cdot (G_{.j})^{-1} \right) - S_i \cdot cv_i \quad (20)$$

Finally, the last method is a complete non-compensatory method, namely the geometric mean. It is defined as

$$C_i^{MGEO} = \sqrt{\prod_{j=1}^{2} r_{ij}} \quad (21)$$

The idea behind the use of a geometric mean is that if a country reaches the minimum value in one dimension [50], this component should be not compensated by a high performance in the second dimension, as occurs for the arithmetic average [51–53]. A comparison of the corresponding rankings contributes to identify the countries with the best and worst performance [54], delineating optimal aggregation rules for our data (e.g., [55]). Finally, we compare the ranking obtained using this aggregation rule with expenditure on educational institutions as a percentage of Gross Domestic Product (GDP). Following [56], this exercise aimed at verifying the eventual relationship between input (expenditure side) and output (namely the 'opportunities' and 'mobility' dimensions characteristic of tertiary education).

3. Results

3.1. Ranking OECD Countries through 'Mobility' and 'Opportunity' Indexes

We computed the Mobility Index (MI) and the Opportunity Index (OI) for 26 OECD countries (Table 1). The highest ranks indicate the best performances as far as the specific dimension was concerned. MI ranges from 0.451 to 0.801, with an average value of 0.630 and a standard deviation amounting to 0.102. Moreover, 16 countries ranked above the average, outlining a slightly negative asymmetry (−0.25) of the statistical distribution of ranks. Finland showed the highest level of mobility, meaning that parents' education does not (negatively) affect the probability for a child to reach tertiary education. Children display almost the same probability to graduate whether their parents have (or do not have) tertiary education. Canada and Estonia occupy the second and third positions, with very similar values. Chile, Italy, and Turkey ranked bottom. For these countries, the parents' education has a great impact on the probability of graduating, meaning that the family of origin matters. However, low upward mobility does not necessarily indicate a smaller opportunity to attain high levels of education. For instance, upward mobility may be low in countries where a large share of parents have already attained tertiary education. For this reason, we introduce another index: estimating the loss of 'opportunities'. This index, namely OI, ranked OECD countries along a statistical distribution with an average score of 0.40, a standard error of 0.025, a minimum of 0.14, and a maximum of 0.60. Canada, Israel, and New Zealand totalized the highest values of the opportunity index. Turkey, Italy, and Austria ranked bottom.

Table 1. OECD country ranking based on the Mobility Index (MI, left) and the Opportunity Index (OI, right).

Rank	Country	Mobility MI	Rank	Country	Opportunities OI
1	Finland	0.801	1	Canada	0.605
2	Canada	0.760	2	Israel	0.571
3	Estonia	0.759	3	New Zealand	0.564
4	New Zealand	0.752	4	Japan	0.533

5	Austria	0.731	5	Korea	0.528
6	Sweden	0.726	6	Finland	0.518
7	Netherlands	0.705	7	Norway	0.476
8	Norway	0.700	8	Denmark	0.468
9	Korea	0.691	9	Estonia	0.452
10	Japan	0.669	10	Australia	0.451
11	Denmark	0.667	11	Ireland	0.438
12	Slovenia	0.665	12	United States	0.427
13	Germany	0.647	13	France	0.406
14	Australia	0.634	14	Netherlands	0.403
15	United States	0.621	15	Sweden	0.393
16	Israel	0.618	16	Spain	0.373
17	Ireland	0.606	17	Germany	0.371
18	Spain	0.596	18	Poland	0.360
19	Greece	0.559	19	Chile	0.343
20	Czech Republic	0.541	20	Slovenia	0.332
21	France	0.538	21	Greece	0.295
22	Poland	0.497	22	Czech Republic	0.231
23	Slovak Republic	0.496	23	Slovak Republic	0.230
24	Chile	0.479	24	Austria	0.210
25	Italy	0.462	25	Italy	0.166
26	Turkey	0.451	26	Turkey	0.143

3.2. The Empirical Relationship between 'Mobility' and 'Opportunity'

Figure 2 illustrates the empirical relationship between MI and OI, evidencing how the two rankings do not coincide. Parametric (Pearson) and non-parametric (Spearman) rank–order correlation coefficients were run with the aim of measuring strength and direction of the association between MI and OI, evidencing a moderately positive relationship (Spearman r = 0.634; Pearson r = 0.665, both $n = 26$ countries). Similar coefficients of both parametric and non-parametric correlations indicate that the relationship is linear and allows to conclude that MI is directly proportional to OI. However, both correlation coefficients indicate an imperfect correlation between the two rankings, and as a result, MI and OI seem to capture two partly different aspects of education. In all cases, when the two rankings diverge, further criteria are required to identify which country performs best.

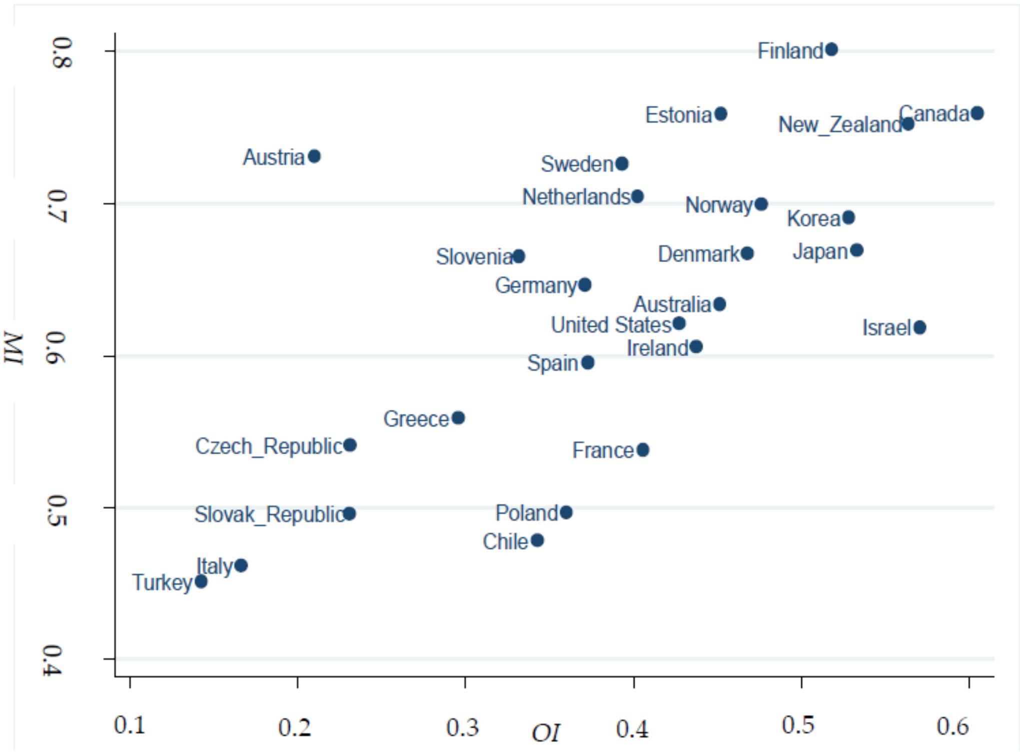

Figure 2. The relationship between Mobility Index (*MI*) and Opportunity Index (*OI*) in OECD countries.

To clarify this point, we compare the results for two countries, namely Finland and New Zealand. According to *MI*, Finland and New Zealand ranked first (*MI* = 0.801) and fourth (*MI* = 0.723). However, if we look at the OI ranking, New Zealand and Finland rank third (*OI* = 0.564) and sixth (*OI* = 0.518), respectively. Keeping these two dimensions distinct, and assuming the synergic role of both aspects, it is rather difficult to determine the overall position of countries as far as intergenerational education attainment is concerned. Based on these premises, the two dimensions were thus combined. The next section is devoted to presenting the results of methodologies deriving a composite indicator that accounts for the two dimensions together.

3.3. A New Indicator Composing 'Mobility' and 'Opportunities' in Tertiary Education

We calculated a new indicator composing 'mobility' and 'opportunities' indexes based on seven aggregation methodologies ([46,57–59]) that provided similar results, as shown in Table 2 (descriptive statistics). The penalization function does not affect the average value of the index, decreasing only by 0.5. GAMPI has the lowest value, whereas *GW*. has the highest value, with similar ranges observed throughout. All methods identified a negative asymmetry in the statistical distribution of the respective composite indicator.

Table 2. Descriptive statistics of the results of different aggregation methods for construction of a composite indicator of tertiary education long-term sustainability (for abbreviations, see Chapter 2).

Statistics	EW	AMPI	GW.	iG	GAMPI	iGAMPI	GM
Mean	100.0	99.5	100.0	100.0	99.5	99.5	99.8
Standard Error	3.03	3.04	3.03	3.10	3.05	3.10	3.03
Median	101.0	100.8	102.22	102.1	102.1	100.8	100.9
Kurtosis	−0.51	−0.599	−0.474	−0.638	−0.594	−0.675	−0.551
Asymmetry	−0.41	−0.357	−0.408	−0.392	−0.361	−0.344	−0.385
Range	56.4	56.4	57.6	56.2	57.6	55.9	56.4

Min	68.3	68.7	67.9	68.7	67.9	68.7	68.3
Max	124.7	124.7	125.5	124.9	125.5	124.5	124.7

A country's ranking based on the statistical distribution of the seven composite indicators derived from the adopted aggregation methods was illustrated in Table 3. Country rankings were stable all over the adopted aggregations, both for high-rank entries and for low-rank entries.

Table 3. Country rankings of a composite indicator of mobility–opportunities reflecting long-term sustainability in tertiary education by aggregation method (for abbreviations, see Chapter 2).

Country	EW	AMPI	GW	iG	GAMPI	iGAMPI	GM
Australia	12	12	11	13	10	12	12
Austria	17	18	19	12	22	16	18
Canada	1	1	1	2	1	2	1
Chile	22	22	22	23	21	23	22
Czech Republic	23	23	23	22	23	21	23
Denmark	10	9	9	10	9	10	9
Estonia	4	4	7	4	7	4	4
Finland	2	2	3	1	3	1	2
France	19	19	18	19	18	19	19
Germany	15	15	15	15	15	13	15
Greece	20	20	21	20	20	20	20
Ireland	14	14	14	17	14	17	14
Israel	8	8	5	11	6	11	8
Italy	25	25	25	25	25	25	25
Japan	6	6	6	8	5	7	6
Korea	5	5	4	5	4	5	5
Netherlands	11	11	12	9	12	9	11
New Zealand	3	3	2	3	2	3	3
Norway	7	7	8	6	8	6	7
Poland	21	21	20	21	19	22	21
Slovak Republic	24	24	24	24	24	24	24
Slovenia	16	16	16	14	16	14	16
Spain	18	17	17	18	17	18	17
Sweden	9	10	10	7	11	8	10
Turkey	26	26	26	26	26	26	26
United States	13	13	13	16	13	15	13

The overall variability of the scores derived from the seven aggregation methods is relatively low, justifying a refined distributional analysis of countries' scores using quintiles (Table 4). Most of the rows present very high values, meaning that the rank's quintile for a given country does not vary considerably. When moving from one aggregation methodology to another, the analyzed countries persisted in the same quintile ranking 15 out of 26 times. For instance, Canada always fell in the first quintile, Denmark in the second, and Germany in the third.

Table 4. Number of times (ranging from zero to seven) a given country was classified in the same quintile (q1 to q5) of the composite indicator of mobility–opportunities in tertiary education across the seven aggregation measures.

OECD Country	q1	q2	q3	q4	q5
Australia	0	2	5	0	0
Austria	0	0	2	4	1
Canada	7	0	0	0	0
Chile	0	0	0	1	6
Czech Republic	0	0	0	1	6
Denmark	0	7	0	0	0
Estonia	5	2	0	0	0
Finland	7	0	0	0	0
France	0	0	0	7	0
Germany	0	0	7	0	0
Greece	0	0	0	7	0
Ireland	0	0	5	2	0
Israel	2	5	0	0	0
Italy	0	0	0	0	7
Japan	5	2	0	0	0
Korea	7	0	0	0	0
Netherlands	0	5	2	0	0
New Zealand	7	0	0	0	0
Norway	2	5	0	0	0
Poland	0	0	0	6	1
Slovak Republic	0	0	0	0	7
Slovenia	0	0	7	0	0
Spain	0	0	0	7	0
Sweden	0	7	0	0	0
Turkey	0	0	0	0	7
United States	0	0	7	0	0

With regard to the values of the composite indicator, Figure 3 presents some box plots (associated with the statistical distribution resulting from each aggregation methodology) that confirm how all the approaches considered in this study produce similar results. In sum, we find that the rankings are not reversed for a wide set of aggregation schemes. Thus, according to [60,61], the proposed index shows a substantial robustness. Finally, Table 5 reports the country ranking according to the seven methods. At the bottom of the ranking, Turkey and Italy occupy the last positions, whereas at the top, Canada fluctuates between the first (5 out of 7 methods) and second rank (2 out of 7 methods).

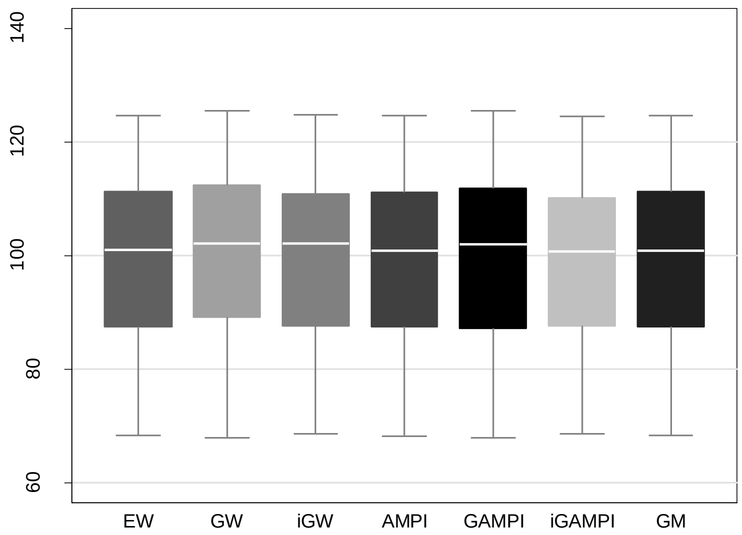

Figure 3. Descriptive statistics (box plot) of the absolute values of a composite indicator of mobility–opportunities in tertiary education by aggregation method (for abbreviations, see Chapter 2).

Table 5. Country rankings (quintile) of a composite indicator of mobility–opportunities reflecting long-term sustainability in tertiary education by aggregation method (for abbreviations, see Chapter 2).

Country	EW	AMPI	GW	iG	GAMPI	iGAMPI	GM
Australia	3	3	2	3	2	3	3
Austria	4	4	4	3	5	3	4
Canada	1	1	1	1	1	1	1
Chile	5	5	5	5	4	5	5
Czech Republic	5	5	5	5	5	4	5
Denmark	2	2	2	2	2	2	2
Estonia	1	1	2	1	2	1	1
Finland	1	1	1	1	1	1	1
France	4	4	4	4	4	4	4
Germany	3	3	3	3	3	3	3
Greece	4	4	4	4	4	4	4
Ireland	3	3	3	4	3	4	3
Israel	2	2	1	2	1	2	2
Italy	5	5	5	5	5	5	5
Japan	1	1	1	2	1	2	1
Korea	1	1	1	1	1	1	1
Netherlands	2	2	3	2	3	2	2
New Zealand	1	1	1	1	1	1	1
Norway	2	2	2	1	2	1	2
Poland	4	4	4	4	4	5	4
Slovak Republic	5	5	5	5	5	5	5
Slovenia	3	3	3	3	3	3	3
Spain	4	4	4	4	4	4	4
Sweden	2	2	2	2	2	2	2
Turkey	5	5	5	5	5	5	5
United States	3	3	3	3	3	3	3

Table 5 reports the quintiles for each indicator, so we can establish whether one or more methods rank differently. The results show that EW, AMPI, and GM display identical quintiles. When the quintiles differ across methods for a given country, GW and GAMPI show similar results in almost all countries. Counting the number of times there are differences among the rankings, we find that GAMPI differs the most (6 times, compared with 5 times for iGAMPI, 4 for GW, and 3 for iG).

To confirm our assumption about ranking stability, we also compute a correlation analysis of country rankings distinguishing the results of each of the seven methods (Figure 4), suggesting that all rankings were highly correlated. With respect to correlation coefficients (Table 6), the indicator with the highest association with all other methods is EW. This result suggests how such a method can be used as the most effective aggregation method. Additionally, the correlation between EW and AMPI is 0.999, which means that the two approaches rank countries almost in the same way. Thus, from a computational point of view, EW and AMPI are the same. Since EW shows similar correlations with respect to all methods, we finally adopted the EW method for further analysis.

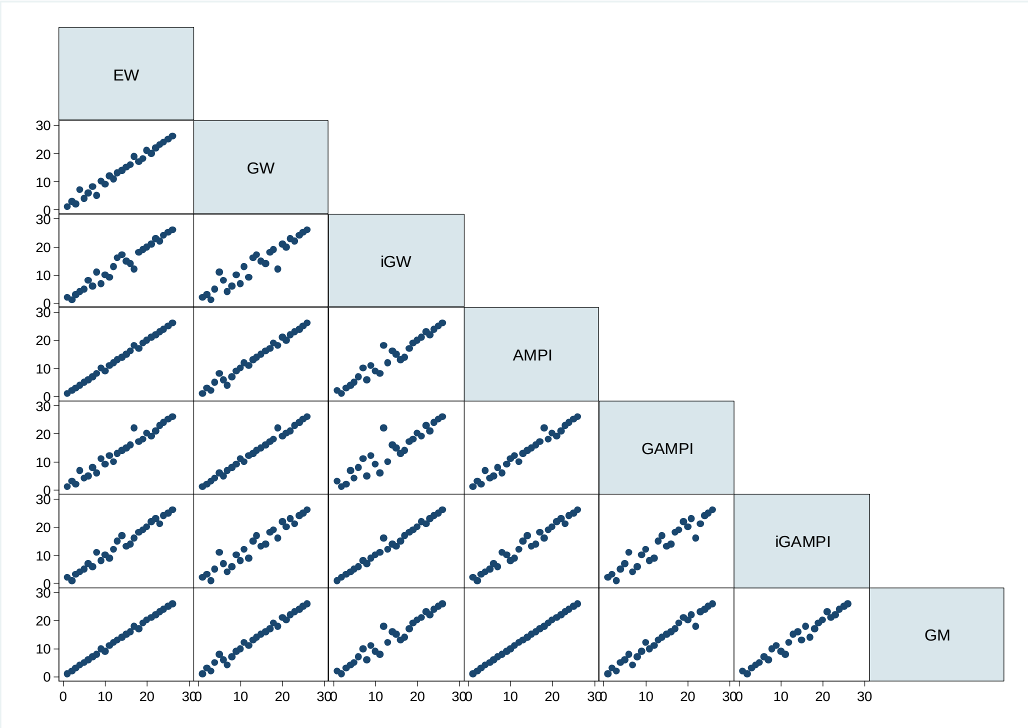

Figure 4. Pair-wise correlation between the results of different aggregation methodologies in OECD countries (for abbreviations, see text).

Table 6. Results of a Spearman rank correlation analysis showing coefficients that estimate the intensity of the pair-wise relationship between the results of different aggregation methods.

Aggregation	EW	GW	iGW	AMPI	GAMPI	iGAMPI
GW	0.989					
iGW	0.975	0.945				
AMPI	0.999	0.990	0.969			
GAMPI	0.980	0.995	0.924	0.984		
iGAMPI	0.984	0.961	0.991	0.982	0.949	
GM	0.999	0.990	0.969	1	0.984	0.981

3.4. Exploring the Relationship with National Expenditure in Education

We finally verified both intensity and statistical significance of the pair-wise relationship between EW and the total expenditure of educational institutions as a percentage of GDP per level of education, and we specifically focus on the expenditure on tertiary education. We compute the correlation between the composite indicator constructed using the equal weight method and the overall level of expenditure on tertiary education as a percentage of GDP. The relatively low value of the correlation coefficient (r = 0.495) documents a moderate linkage between the two variables. Results of this analysis were explicitly illustrated in Figure 5, from which some interesting conclusions can be drawn. First, Turkey and Italy have the lowest performance according to our composite index, but their percentages of expenditure on tertiary education are very different since the situation in Italy seems better than in Turkey. Second, Turkey, Austria, and Finland seem to have the same percentage of expenditure, but the results of the composite indicator are very different, since Finland ranked first, and Turkey last. So, it seems that it is not enough to increase the percentage of GDP devoted to education, especially for countries with low levels of GDP. Figure 5 also compares European countries (diamonds; n = 17) with non-European countries (circles; n = 9). For European countries, the level of correlation between total expenditure on tertiary education and our composite indicator of long-term sustainability in tertiary education systems is very high (0.792 on average) compared with the level of correlation observed for non-European countries (0.176, on average). In other words, a lower level of expenditure on tertiary education corresponds to lower values of the composite indicator only in European countries.

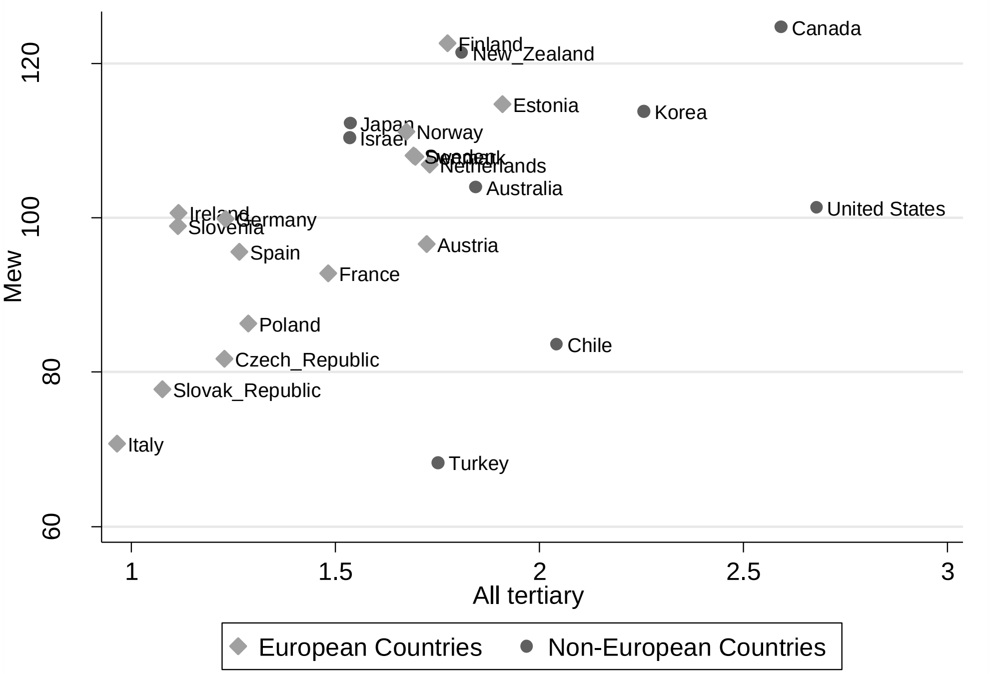

Figure 5. The relationship between the composite indicator of long-term sustainability in tertiary education systems ('Mew') and the level of expenditure for tertiary education in total GDP ('All tertiary') in OECD countries.

4. Discussion

Assuming that children can graduate more easily if they come from a family of graduates, we investigated different aspects of mobility and opportunity in tertiary education, using OECD data for 26 advanced economies [14]. Since the two dimensions were demonstrated to provide diverging results [47,51,52], we created a composite indicator testing the impact of seven different aggregation methods [57,58,62]. This indicator was considered a novel contribution to monitoring the effectiveness of public policies in the field of education. The main advantage of this approach is that, unlike the 'mobility' indices that consider only one dimension, here two different dimensions were captured simultaneously (namely the difference in the probability of attaining tertiary education with the given family status and the probability that a child will not reach tertiary education, regardless of the education level attained by the parents).

Looking at the empirical results of this study, we found that the seven methods rank OECD countries similarly, and we selected the method that correlates better with the other computational approaches [48]. Based on this dataset, we found that the equal weight method is the most appropriate [46], and we propose it as the preferred aggregate method [63]. From a computational point of view, the empirical results of our study indicate that refined methodologies such as Mazziotta–Pareto or GW approaches—i.e., modifications of the arithmetic mean aggregation with weights based on the Gini index of inequality—give rankings that do not differ much with respect to the rankings computed according to the arithmetic mean (namely, the EW method). Since the arithmetic mean is the simplest aggregation method [60], we selected it as the preferred approach because it is simple to calculate, especially for policy makers and/or practitioners (e.g., [61,64]).

The composite indicator defined in this study may thus represent a useful tool for monitoring and evaluating the effectiveness of public policies in the field of education [6,19,20]. The main advantage of our framework is that, in contrast to the mobility indices that consider only one dimension (e.g., [5]), here we are able to capture two different pieces of information simultaneously [21]: (i) the difference in the probability of attaining tertiary education given the family status [40–42], and (ii) the probability that a child does not attain tertiary education independent of the educational level attained by the parents [9,12,13]. Thus, our approach is informative while preserving a simple functional form that requires elementary computation [15,26,65].

Being grounded on the international debate on the importance of (public) investment in national education systems [30,63,66], a comparative analysis of the relationship between the composite indicator of long-term sustainability in tertiary education systems [24,56,67] and the expenditure in tertiary education (as per cent share of GDP) demonstrates how European and non-European countries display different patterns [68], with a significant correlation between the two variables found for European countries only [62,69–71]. The inherent reduction of these expenditure gaps may represent an effective contribution to reach more inclusive and equal tertiary education systems, contributing substantially to a more sustainable development path of countries as far as the education dimension is concerned.

5. Conclusions

Driven by the idea that children can graduate more easily if they come from a family of graduates, our study assesses 'mobility' and 'opportunity' through original measures that provide a ranking of OECD countries intended as a basic knowledge supporting and directing public policies and the level of expenditure in tertiary education. Altogether, the results of our study justify further investigations in the field of educational attainment and family background. Improvements in both theoretical and operational grounds are particularly appropriate in this research issue. First, from an operational point of view, looking at per capita levels of expenditure in tertiary education instead of the level of expenditure as a share of GDP may shed additional insights in the analysis of education systems' efficiency in a cross section of countries. Second, from a theoretical point of view, a parametric aggregation method where the choice of parameter(s) could be a function that reflects several aspects of well-being should be developed, for instance by maximizing the proportion of explained variance in the model. Conceptually speaking, these improvements should clearly document how universities play an important role in ensuring social mobility. As a result, government policies should better support universities to promote social mobility by encouraging recruitment of students coming from disadvantaged backgrounds. Improvements in the quality of statistical data describing tertiary education systems at the country scale are ultimately necessary to reach this important target from both positive and normative perspectives.

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