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Measuring Inequality of Opportunity in Access to Quality Basic Education: A Case Study in Florida, US

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Abstract: Providing all children equal access to essential services, such as primary education, has been set as a priority in the Sustainable Development Goals (SDG)' agenda during the last two decades. Yet the Global Education Monitoring report in 2016 reveals that wide disparities between the rich and the poor persist in access to education of high quality. This study uses the Human Opportunity Index (HOI) to examine the equality of opportunity in access to basic education of high quality. By using enrollment and admission data from a case study in a large school district in the US in 2015/2016, this research evaluates the capacity of the HOI, in order to reveal disparities in access to school opportunities and examines how much of this inequality is explained by families' pre-determined circumstances. The way of analyzing equality is by disaggregating applications' data into circumstance groups, according to gender, geography, race/ethnicity, and other criteria. To capture the contribution of each circumstance to inequality of opportunity, the Shapley decomposition method is used. Findings show that the HOI is capable of systematically monitoring and examining existing admission policies and identifying inequality problems. Furthermore, the analysis of the contribution of each circumstance group can reveal admission criteria that have the potential to harm the educational opportunities for children. This assessment should provide valuable insights into the capability of the indicators to reveal where policy intervention is necessary and supply points of view on how policy can be improved.

Keywords: Sustainable Development Goals; inequality of opportunity; educational inequality; Human Opportunity Index; school admission; Florida

1. Introduction

Quality basic education has been recognized as being at the core of sustainable development. Providing all children equal access to essential services, such as clean water, improved sanitation, or primary education, has been set as a priority in the Sustainable Development Goals' (SDG) agenda over the past 15 years [1]. The ultimate goal of the 2030 Agenda for Sustainable Development is "To leave no one behind" [1]. Education was set as a priority, being considered the most vital input for every dimension of sustainable development, set to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." [1].

Yet the Global Education Monitoring (GEM) report in 2016 [2] raises an alarm since over the past two decades social inequalities have increased, calling for urgent action for education. It reveals that

wide disparities between the rich and the poor persist in access to education of good quality, within and between countries. Even worse, according to the World Development Report 2018, a vast number of children in the world are not benefiting from being well prepared by the schools [3]. In low-income countries, "only 36% among the poorest youth complete primary education; less than half of children complete lower secondary school, only 14% complete upper secondary education, and girls continue to lag behind boys" [4].

Equity concerns in education are addressed in target 4.5 of the SDGs, set "to eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable" [1]. This target seeks the development of strategies for equalizing access for the groups that are most under-served, vulnerable and disadvantaged, regarding access to quality learning opportunities. These groups include persons with disabilities, indigenous peoples, ethnic minorities, children at risk, and the poor [1]. The progress of this target is measured by indicators which are still undergoing methodological development [5].

Equality of opportunity is based on the idea of giving people equal opportunity early in life, whatever their socioeconomic background, so that everybody has the same chance to be successful [6]. In his seminal contribution on equality of opportunity, Roemer [6] identifies two types of factors that determine individual outcomes: (1) factors over which individuals have control, named "efforts", i.e., autonomous choices made by individuals, such as studying hard at school; and (2) factors for which individuals cannot be held responsible, named "circumstances". Children's pre-determined circumstances are a set of personal, family or community characteristics inherited from their families and the location at birth, beyond their control [6–10].

The central argument is that in a world of equal opportunities, the circumstances should not matter. According to this, success in life should reflect a person's choices, efforts, and talents, not their background [11]. For instance, when requesting admission to a selective school, all applicants will have equal opportunity to become well educated if the only obstacle they face, all other things being equal, is passing an entrance audition or a test that reflects personal choices, efforts, and talents; or luck. It is expected that the opportunity to get admission is not influenced by children's circumstances such as gender, parental education, race, nationality, or religion.

Educational opportunities refer to "opportunities that aim to enable individuals to acquire knowledge and certain skills, and to cultivate certain capacities" [12]. Stiglitz [13] shows that, even in developed countries such as the United States and in Europe, unfairness in schooling can still be strongly perceived: "wealthy parents send their children to the best primary and high schools, and those students have a far better chance of getting into the elite universities, who also have a better chance at getting the good jobs" [13].

According to the World Inequality Report in 2018 [14], the income inequality observed in the United States is largely due to massive educational inequalities. More than fifty years ago, a landmark study led by Coleman in the US [15], "Equality of Educational Opportunity", reported that the large majority of American children attended schools that were largely segregated by race. Because neighborhoods are racially segregated, and school is a local service, this can lead to schools also divided by race. In 2015, 40.6% of African-American students in public schools attended high-poverty schools compared to just 7.9% of white students [16].

In many states in the US, including Florida, public education is run by local towns and funded by municipalities creating a strong link between local property taxes and school funding; i.e., unequal tax bases create unequal schools [6]. Moreover, the scarcity of high-quality primary and secondary education is evident, restricted to children whose families can afford housing in wealthy neighborhoods, or who have access to private schools via tuition or scholarships [12].

The 2016 World Social Science Report [17] indicates that racial inequality has persisted for decades in the US, despite the state establishing anti-discrimination legislation to eliminate racial bias. The report informs: "A large gap—in education, income, wealth, health and justice—persists particularly between white and black Americans . . . and these disparities have largely remained

the same over the years ... " [17]. It concludes: "The life prospects of a young kid in the US is more dependent on the education and income of his parents than in any other industrial country in the world" [17].

Equity issues in SDG are currently measured using Parity Indices (PI) [2]. PI show the relative access to a service among different groups of the population. Analysis of educational disparities is currently possible by sex (female/male), location (rural/urban) and household wealth (bottom/top wealth quintile) for all education indicators that can be disaggregated. PI simply divide the indicator (e.g., primary completion rate) value for one group (e.g., women) by the value for a comparison group (e.g., men). PI has some drawbacks, such as being sensitive to low values and not representing the scale of disadvantage symmetrically around one [18]. The GEM report in 2016 addresses issues for SDG target 4.5 and calls for the inclusion of broader aspects of equity in education, beyond parity [2]. It asks for considering the contributing causes of the inequalities and giving more attention to vulnerable populations, including people with disabilities, minorities, migrants, and children whose language of instruction is not the same as the language spoken at home.

We argue that the Human Opportunity Index (HOI) [19], a tool to measure the distribution of opportunities, can be used to measure equitable access to education. The HOI, first presented by Paes de Barros and colleagues [19], carries information about the coverage rate of the service, i.e., the fraction of children who have access to educational services, but also how fairly the available places are distributed among children of different backgrounds [7]. The HOI captures the degree of inequality in multiple indicators (e.g., enrollment, achievement, admission) into one single measure, while PI requires individual analysis of each indicator.

This paper seeks to contribute to the literature by measuring the distribution of opportunities along two dimensions in the education of a young population: first, attainment, captured through enrollment profiles at schools; and second, admission, captured through student applications to schools. We further investigate the differences in distributions when we add the quality of the school. Using a case study in a large school district in the US, this study attempts to estimate the degree to which the HOI can reveal disparities in access to school opportunities for children 11–13 years old, and how much of this inequality is explained by families' pre-determined circumstances.

Consequently, the paper aims to provide an answer to the following specific questions: (1) How equal is the distribution of opportunity among groups in different circumstances? (2) How much does each circumstance contribute to the total inequality in opportunities (IOP)? (3) To what extent can HOI reveal inequalities in access to high-quality education?

Section 2 of this paper explains the problem setting, introduces the HOI methodology and prior studies using it and presents the opportunities to be assessed and the set of circumstances selected for the case study, given the data available for the school district. Section 3 describes the main opportunity gaps across individual circumstances and identifies the most important contributors. Section 4 summarizes and Section 5 concludes.

2. Materials and Methods

Most children in the US are assigned a public school in the attendance zone, according to the place of residence. In contrast, school choice gives parents more control over their child's education, allowing them to choose where and how their children are educated. In most school choice procedures parents are asked to submit a rank list of preferred schools. Similarly, schools have a number of available places and they rank applicants according to specific priority criteria that reflect the district's policies. A matching of students and schools determines the assignment of each student. The 'best' schools are the ones for which most parents wish to gain admission. When the number of families' expressed preferences for a school exceeds its number of available places, the admission authority uses over-subscription criteria to decide who gets the place. The student assignment problem is described by Malczewski & Jackson [20] as an "educational resource allocation problem."

During the past few decades, economists have been actively designing Student Assignment Plans (SAP). A few relevant examples include the Netherlands [21], Turkey [22], New York [23], Boston [24] and Chicago [25], among many others. Most of this work has been in the design and adaptation of the matching mechanisms for a school assignment. In contrast, our research focuses on the second component of the problem, studying the criteria schools establish for ranking students who apply for admission.

School priorities can be based on multiple criteria, such as having siblings, being a skilled student, having a specific socioeconomic status (based on race, income, spoken language), or living near the school, among others. It has been demonstrated that the set of rules that define admission, and the priority points assigned to students, also play an essential role in the final allocation of students [26,27]. Some schools appear to avoid certain types of students, limiting access for the most disadvantaged [28]. Some parents may face uncertainty about their own priorities when submitting preferences, due to the role of the school priorities [29,30].

We investigate the student admission criteria and measure the equality of opportunities that happen when a middle-level student requests admission to a specialty school in a large school district in Florida. The analysis focuses on investigating the impact of using priorities for student admission and whether these priorities provide equal opportunities to all families. The way of analyzing equality is by disaggregating application data into circumstance groups, according to gender, geography, race/ethnicity, and other criteria. The focus is on understanding how much children's personal circumstances—such as gender, race, the location of birth, socioeconomic and demographic origin, or their family background—are considered by the schools in the admission criteria and whether this affects the access that children get to basic education of good quality.

2.1. Case Study and Data

The case study is the School District of Hillsborough County (SDHC), which serves the city of Tampa, Florida, and its metropolitan area. SDHC is the eighth largest school district in the US with nearly 206,000 students in about 279 K-12 public schools [31]. More than 50,000 students attend a school through one of the district's many school choice programs. SDHC Magnet schools serve 8.5% of the total school district population (17,700 enrolled students) in the 2015–2016 academic year.

The diverse characteristics of the SDHC enrolled population, the legacy of school desegregation issues and civil rights in black schools [32,33], and the strong association of racial distribution of students across schools and academic achievement found in previous research [34], make Hillsborough county well suited for studying equality of educational opportunities.

The focus of this study is the choice of magnet programs at middle (sixth, seventh, and eighth) school grades. Magnet schools are designed to attract pupils from various areas, offering a specialized curriculum that would draw students from across the defined geographical boundaries, based on their interest in themes such as math, music or sciences. Transportation is provided at no cost to families to almost all magnet schools. They emerged in the US as one means to eliminate, reduce, and prevent minority group isolation [35]. They tend to perform well and have a more diverse student population than neighborhood schools.

There is a consensus that more and better data are key to measuring progress towards the SDGs. In many countries data for several important indicators to measure equity in education are unavailable because those indicators require fine disaggregation among different groups in the population. Standard measures of inequality often rely on household surveys which usually underestimate the income and wealth of individuals at the top levels [14]. There is a call to host initiatives designed to integrate data from non-traditional sources, such as satellite imagery, school censuses, learning assessments and incorporating data by municipal and neighborhood levels. To overcome current limitations, we rely on the combination of data at the individual and school levels from three different data sources: school enrollment data, school accountability data, and student applications data for the SDHC academic year 2015/16.

The first dataset contains the profiles of school enrollment for all middle schools in the district. This dataset was obtained from the National Center for Education Statistics (NCES) Common Core of Data [31], an annual national database of all public elementary and secondary schools in the US. It contains enrollment information for the academic year 2014/15 on basic socio-economic characteristics of the school population, as exhibited in Table 1, including the distribution (count of the number of students) for each subgroup on the following circumstance variables: school meal recipients (free/reduced, paid), gender (male, female), and race/ethnicity (black, hispanic, white and other).

Table 1. School enrollment data for SDHC magnet middle school programs for the 2015/2016 academic year.

ALT	School Name	School Grade	Urban Locale	Title I School	Total Students	Lunch Status		Gender	
						FRL	PAY	M	F
S1	Stewart	A	CL	YES	857	70%	30%	65%	35%
S2	Dowdell	C	SL	YES	613	92%	8%	54%	46%
S3	Sligh	F	CL	YES	648	95%	5%	50%	50%
S4	Franklin (Boys) Magnet	A	CL	YES	419	68%	32%	100%	0%
S5	Ferrell (Girls) Magnet	A	CL	YES	405	74%	26%	0%	100%
S6	Orange Grove Magnet	A	CL	NO	562	48%	52%	30%	70%
S7	Progress Village	A	SL	NO	865	55%	45%	34%	66%
S8	Roland Park K-8 Magnet	A	CL	NO	763	42%	58%	52%	48%
S9	Rampello K-8	A	CL	NO	766	45%	55%	49%	51%
S10	Walker Magnet	A	RF	NO	900	38%	62%	49%	51%
S11	Williams	A	CL	NO	798	38%	62%	52%	48%
S12	Young Magnet	C	CL	YES	561	88%	12%	58%	42%
	Total Magnet Middle				8157	60%	40%	50%	50%
	Total Enrolled Population				207,469				

Note: ALT: Alternative Code; NCES Urban Locale: Citi, Large (CL); Suburban, Large (SL); Rural, Fringe (RF); Lunch Status: Free/Reduced (FRL), Paid (PAY); Student Gender: Male (M), Female (F). FDOE School Grading Scale: A = 62% of points or greater, B = 54% to 61% of points, C = 41% to 53% of points, D = 32% to 40% of points, F = 31% of points or less.

The second dataset comprises school accountability data that gives information about the quality of education delivered for each school, collected by the Florida Department of Education (FDOE) for the year 2014/15. This dataset holds information about student performance on statewide standardized assessments [36]. School quality is measured by the school grades, a way to measure the performance of a school. The school grade formula includes achievement components (English language, arts, mathematics, science, and social studies), learning gains, graduation rates, and college and career acceleration components. This school grading system conveys the achievement level of Florida's schools and reflects student outcomes, and therefore can be used to understand how well each school is serving its students [36].

The third dataset consists of geocoded applications to magnet middle schools in SDHC, for the academic year 2015–2016. This geographic dataset contains secure and anonymized applicant's records including preferred schools, home location, and demographic details of the applicants. School-level data provides information about the characteristics of available school programs and geographic boundaries of school service areas. Table 2 shows simple information about the SDHC magnet middle school dataset including 7798 ranked choices made by 3723 applicants to 12 magnet middle school programs. Applicants rank up to three schools in the application. The first ranked school is used for this study, as it captures an applicant's most desired choice. The number of categories for each circumstance variable was reduced to four or fewer, in order to reduce the number of types with zero or few observations in the dataset.

Table 2. SDHC magnet middle enrolled population and applications by race/ethnicity for the 2015–2016 academic year.

ALT	School	Program	FDOE	Total Enrolled	Enrolled Population				Total All Ranked	All Ranked Applications			
			Theme	Population	BLA	WHI	HIS	XOT	Applications	BLA	WHI	HIS	XOT
S1	Stewart	Math/Science/Technology	MAT	857	34%	24%	35%	7%	1011	27%	33%	27%	13%
S2	Dowdell	Environmental Studies	OTH	613	28%	19%	49%	4%	283	27%	36%	29%	8%
S3	Sligh	Health Professions	OTH	648	76%	4%	16%	4%	339	38%	32%	18%	12%
S4	Franklin (Boys) Magnet	Boys Preparatory Academy	OTH	419	42%	26%	24%	8%	480	44%	25%	23%	8%
S5	Ferrell (Girls) Magnet	Girls Preparatory Academy	OTH	405	42%	24%	26%	8%	581	43%	28%	19%	10%
S6	Orange Grove Magnet	Visual/Performing/Arts	ART	562	31%	33%	30%	6%	1008	46%	26%	20%	8%
S7	Progress Village	Visual/Performing/Comm. Arts	ART	865	29%	36%	28%	7%	861	32%	31%	28%	9%
S8	Roland Park K-8 Magnet	International Baccalaureate	IB	763	28%	29%	27%	16%	563	22%	33%	24%	21%
S9	Rampello Downtown K-8	Cultural Arts & Humanities	OTH	766	32%	34%	29%	5%	210	37%	30%	25%	8%
S10	Walker Magnet	International Baccalaureate	IB	900	12%	42%	31%	15%	764	13%	23%	42%	22%
S11	Williams	International Baccalaureate	IB	798	29%	23%	19%	29%	779	33%	18%	22%	27%
S12	Young Magnet	Creative Science Centre	MAT	561	52%	13%	30%	5%	919	48%	25%	18%	9%
	Total magnet middle schools			**8157**	2816	2171	2355	815	**7798**	2692	1911	2141	1054
					34%	27%	29%	10%		34%	25%	27%	14%
	Total enrolled population			**207,469**	44,402	74,336	71,971	16,760					
					21%	36%	35%	8%					

Note. ALT: Alternative code; Theme Specialty: MAT (Sciences/Math), ART (Performing Arts), IB (International Baccalaureate), OTH (Other Theme Specialty); Race/Ethnicity: BLA (Black), WHI (White), HIS (Hispanic), XOT (Other Race/Ethnicity).

2.2. Choice of Opportunities

Common measures of education output are coverage rates for school attendance, school enrollment, and timely school completion [37]. Education quality is another key consideration in defining access [38]. The latter is significant because not all schools provide the same quality of instruction [39], some schools may be better than others at helping students learn. Substantial research suggests that school quality highly affects student learning [40].

Indicators of access to education are considered as opportunities available in the children's place of residence, necessary to achieve their human potential [8]. The two indicators of access to education used in this paper are defined as follows: (1) whether a child is enrolled in a school of high-quality; (2) whether a child receives an offer for admission to a school of high-quality. In this context, young children 11 to 13 years of age enrolled/admitted to a high-quality school have the opportunity to be well-educated.

The school letter grade is used to measure the school quality, assigned by the FDOE of A, B, C, D, or F. HOI requires to dichotomize the output (dependent) variable. Therefore, in this work schools are coded as "high-quality" when they are ranked with A or B scores, and "poor-quality" when the schools are ranked with C, D, or F scores.

2.3. Choice of Circumstances

Following Roemer's classification [6], our circumstances are variables specific to the child, including the demographic and socioeconomic status of the household, geographic settings of the household, and the characteristics of the attendance area school. Table 3 shows the set of circumstances considered for this study.

The choice of the circumstances involves subjective judgment. It reflects the priority criteria used for student admission to magnet middle schools at SDHC for the 2015/2016 academic year; this list was supplemented with a common set of variables used by prior studies in educational opportunity [15,39,41,42], and constrained by the data available for the school district for the case study. Note that the assessment of IOP is conditional on observed circumstances, and the indexes change if a different set of circumstances is considered [8].

SDHC utilizes a race-neutral weighted lottery process for student admission. Applicants receive the applicable weight (points) for each of the lottery parameters. The weight only applies to those designated with 'yes' in the column 'admission criteria' in Table 3. Points are accumulated for all criteria and function as 'tickets' for the lottery. The more points an applicant gets, the greater the chance he/she will receive an offer. Since the selection is random, the applied weight does not guarantee admission.

Children who qualify for free and reduced-price lunch (FRL) program are considered low-income; this variable is used as a proxy for the socioeconomic status (SES) of the student. The variable female is a dichotomous variable coded 1 if the student was female and 0 if male. Race/ethnicity was encoded into four categories: black, hispanic, white and other. The reference category is white. Distance from home to school was calculated using the road network. Children with disability in Florida are identified as recipients of exceptional student education, coded 1 when they have any kind of disability and 0 if none. The language spoken at home was encoded as a dichotomous variable coded 1 if English is spoken at home and 0 if any other language is spoken at home.

The last row captures the academic status of the student's assigned attendance area school. A weight (points) is applied for each year a school has not met the accountability factor. In practical terms, this lottery parameter is used to give priority to children residing in an attendance area with high numbers of economically disadvantaged students (assigned to Title I schools, of the Elementary and Secondary Education Act (ESEA)), who are failing, or most at risk of failing, to meet state student academic achievement standards.

Table 3. Choice of circumstances for access to high-quality education.

Type	Purpose	Circumstance	Factors	Admission Criteria
Child characteristics	To capture a direct form of discrimination	Student's race/ethnicity	BLA/WHI/HIS/OTH	NO
		The student has a disability	YES/NO	NO
		The student is female	YES/NO	NO
Household characteristics	To capture family structure	The student has a sibling in the school	YES/NO	YES
		Student's parent is an employee of SDHC	YES/NO	YES
		The Student qualifies for free/reduced-price meals	YES/NO	YES
		Student's home language is English	YES/NO	YES
Location	To capture spatial disparities	Distance from home to selected school (in miles)		NO
		Student's home is located in an urban area	YES/NO	YES
Assigned school characteristics	To capture academic status	Student's assigned school ESEA compliant accountability factor	YES/NO	YES

Note: Race/ethnicity: Black (BLA), White (WHI), Hispanic (HIS), Other race (OTH); Elementary and Secondary Education Act (ESEA). Note that in the admission criteria, SDHC elementary magnet students applying for middle magnet schools are identified and a weight is applied for this parameter. However, this information was not available in the dataset.

2.4. Methods

This section introduces the methodology of HOI following Chapter 2 of Debalen et al. [8] and applied to IOP for education. HOI was first introduced by Paes de Barros et al. [19,43] and Molinas et al. [38]. A complete discussion can be found in Paes de Barros et al. [44].

2.4.1. Opportunity Measures: To be Enrolled in a High-Quality School

The coverage C is the percentage of individuals that have access to the opportunity. The Dissimilarity Index (D-index) D measures the dissimilarity in access to high-quality education for groups defined by circumstance characteristics (e.g., gender, race/ethnicity, location, etc.) compared with the overall coverage rate C of the population as a whole. It is widely used in sociology and applied to dichotomous outcomes.

$$D = \frac{1}{2C} \sum_{i=1}^{n} w_i |C - C_k|$$

where n is the number of circumstance groups. C_i is the coverage of the circumstance group i. w_i is the share of group i in the total population. D ranges from 0 to 1; in a situation of perfect equality of opportunity D will be zero. The greater the variation, the higher the IOP.

The *HOI* is a measure of the coverage rate of an opportunity, discounted by inequality in the distribution across circumstance groups.

$$HOI = (1 - D) \times C$$

The *HOI* tracks cover rates and cover gaps for access to key services among children. The *HOI* ranges from 0 (high inequality) to 100 (universal access). *HOI* increases with overall coverage and decreases with the differences in coverage among circumstance groups.

2.4.2. Opportunity Measures: To Get an Offer from a High-Quality School

For the opportunity to get an offer from a high-quality school, the regression approach is used. Assume that there is a random sample of the population of children with information on whether child i has or doesn't have access to high-quality education ($I_i = 1$ if the child has access and $I_i = 0$ otherwise) and a vector of variables indicating his/her circumstances (e.g., gender, race/ethnicity, location, etc.), $X_i = X_{1i}, X_{2i}, \ldots, X_{mi}$. All children having the same set of circumstances are said to be of the same group type.

In this case, the inequality measures are calculated following six steps [45]. The first step is to estimate a logistic regression model on whether a child i has access to high-quality education, as a function of his or her personal m circumstances, using the maximum likelihood method.

$$Ln\left(\frac{P(I = 1|x_1, \ldots, x_m)}{1 - P(I = 1|x_1, \ldots, x_m)}\right) = \sum_{k=1}^{m} \beta_k(X_k)$$

From the estimation of this logistic regression (1), the coefficient estimates $\hat{\beta}_k$ are obtained. The second step is to obtain for each child, the predicted probability of access to high-quality education $\hat{p}_i$, based on the predicted relationship $\hat{\beta}_k$ and the vector of their circumstances X_{ki}.

$$\hat{p}_i = \frac{\text{Exp}\left(\hat{\beta}_0 + \sum_{k=1}^{m} X_{ki}\hat{\beta}_k\right)}{1 + \text{Exp}\left(\hat{\beta}_0 + \sum_{k=1}^{m} X_{ki}\hat{\beta}_k\right)}$$

In step 3 the computation of the overall coverage rate for the service C follow. The coverage rate summarizes information on what fraction of the population has access to a particular opportunity.

$$C = \sum_{i=1}^{n} w_i\hat{p}_i, \text{ where } n \text{ is the total population and } w_i = \frac{1}{n} \text{ or some sampling weights;}$$

In step 4 the Dissimilarity Index (D-index) $\hat{D}$, is calculated.

$$\hat{D} = \frac{1}{2C} \sum_{i=1}^{n} w_i|\hat{p}_i - C|$$

In step 5, the computation of the penalty P for inequality is obtained. P refers to access to the service that was allocated unfairly.

$$P = C \times \hat{D}$$

The last step is to compute the HOI, discounting a penalty for improperly allocated opportunities from the overall coverage rate C.

$$HOI = C - P$$

The *hoi* module [45] in Stata Version 14.2. was used for the estimations. The *iop* module [46,47] in Stata can also be used to calculate IOP.

2.4.3. Determinants of Inequality: To Get an Offer from a High-Quality School

To capture the contribution of each circumstance to IOP, the Shapley decomposition method is used [48]. This procedure calculates the marginal impact of each of the factors as they are subtracted from the calculations, and then averages these marginal effects over all the possible elimination sequences [48]. The impact of adding a set of circumstances A is computed as follows:

$$D_A = \sum_{S \subseteq N\{A\}} \frac{|s|!(n - |s| - 1)!}{n!}[D(S \cup \{A\}) - D(S)]$$

where N is the set of all circumstances; n is the subset of variables; S is a subset of N that does not contain the particular circumstance A; $D(S)$ is the D-index estimated with the set of circumstances S; $D(S \cup \{A\})$ is the D-index calculated with set of circumstances S and circumstance A. The contribution of a set of circumstances A to the inequality index is defined as:

$$M_A = \frac{D_A}{D(N)}; \text{ where } \sum_{i \in N} M_i = 1$$

See [48] for further methodological details. The *hoishapley* module [49] in Stata version 14.2. was used to compute the decomposition of HOI.

2.5. Prior Studies in Educational Inequalities

There is already a large volume of theory and applied literature on the measurement of equity and on equality of opportunity. Much of this work is focused on economic opportunities but later applied to health and education. See Roemer and Trannoy [50] and Ramos and Van De Gaer [51] for recent literature reviews.

Early work measuring equality of opportunity in education focused on quality (achievement). Ferreira and Gignoux [39] propose two measures of educational opportunity: one, a measure of educational achievement, defined as the variance or standard deviation of the OECD's Program of International Student Assessment (PISA) test scores; second, a measure of educational opportunity, calculated as the share of the variance in test scores that is explained by pre-determined circumstances in a linear regression. Using the enrollment-age profiles and the standardized PISA test scores 2006 applied for Turkey, the same authors report large differences by student's gender, spatial location and family background such as parental education and father's occupation [42]. Schlicht, Stadelmann, and Freitag [52] applied hierarchical regression models using data from the 2006 PISA from the European Union (EU) countries to analyze the impact of education policy conditions on the relationship between children's social background and their educational performance (achievement in mathematics). Similarly, using data from nine US states that participated in the 1999 TIMSS test, Schmidt and colleges [53] explore the extent to which students in different schools have an equal opportunity to learn mathematics.

Among the multiple measures that are available, this study focused on the HOI. HOI is a statistical tool that has been applied over the world for measuring the extent of equality of opportunity in multiple dimensions, such as health, household infrastructure, education, and income, in a given country or region as part of a diagnostic approach. Diagnostic studies for regions include Latin America and the Caribbean [38], Sub Saharan Africa [8], and the Middle East and North Africa [9]. Country-specific applications of the HOI are abundant, some examples include Peru [54], Brazil [55], Colombia [10], Egypt [56] and Vietnam [57]. Country-specific analysis of educational inequalities based on HOI is found for Albania [58], Liberia [59], Turkey [42], and Uruguay [60], among many others.

Worldwide, the Global Education Monitoring Report (GEM) tracks progress towards SDG goal 4, based on the World Inequality Database on Education (WIDE) [61], which compiles data from surveys for over 160 countries. WIDE reports indicators for access, completion, and learning, according to factors associated with inequality such as gender, wealth, location and ethnicity. Complementary, the Handbook on Measuring Equity in Education [62], not only summarizes the most relevant literature on equity but also provides a conceptual framework and methodological guidance in the construction, visualization, and interpretation of the indicators. It discusses five concepts for measuring equity in education: meritocracy, minimum standards, impartially, equality of condition and redistribution [62]. According to this classification, the HOI is considered a combined measure of minimum standards (the access rate) and impartiality (the dissimilarity index).

3. Results

3.1. Opportunity Measures: To Be Enrolled in a High-Quality School

Table 4 shows the distribution of educational opportunities at SDHC, by considering how the enrollment profile varies by population sub-groups given the circumstance variables. The first measure is the general coverage *C* (shown in bold characters), i.e., the percentage of children that have access to the opportunity. Being enrolled in a high-quality school is a privilege for 77.7% of the magnet school population at SDHC, a luxury when it is compared with the 53.5% of all public students at middle level in the District, and with the 54.4% of all public students at middle level in the State of Florida, suggesting that magnet schools provide higher opportunities for access to high quality public education at lower secondary level.

Table 4. Opportunity to be enrolled in a high-quality magnet middle school at SDHC.

Circumstance Variables	All Magnet MIS Population	Enrolled in High-Quality	C_k	α_k	D	HOI
Student Lunch Status						
Pay lunch	3247	3099	*95.4*	39.8		
Free/reduced lunch	4910	3236	*65.9*	60.2		
Subtotal	8157	6335	**77.7**	100.0	9.11	70.58
Student Gender						
Male	4054	3073	*75.8*	49.7		
Female	4103	3262	79.5	50.3		
Subtotal	8157	6335	**77.7**	100.0	1.19	76.74
Student Race/Ethnicity						
Black	2816	1865	*66.2*	34.5		
Hispanic	2355	1779	*75.5*	28.9		
Other	815	740	90.8	10.0		
White	2171	1951	89.9	26.6		
Subtotal	8157	6335	**77.7**	100.0	5.87	73.10

Note: *C*: Overall coverage rate of the service (77.7) for all groups; C_k: coverage rate of the circumstance group *k*; α_k: share of group *k* in total population; *D*: dissimilarity index; *HOI*: human opportunity index.

According to Roemer [6], equality of opportunity is achieved when the distributions of outcomes are identical across social groups defined by the circumstances. The IOP idea is to look at what is happening with the gaps across the population of different socio-economic backgrounds. For that, all groups of circumstances with rates of coverage below the average are identified. We refer to these groups as "vulnerable" to loss of educational opportunity (shown with a grey background in Table 4).

There are no significant disparities in gender. The share of both, the female and male population are close to the overall coverage, and hence the dissimilarity index and the penalty are close to zero. The access rate is roughly the same as the HOI, telling that the distribution of opportunities for both genders is equitable.

In contrast, a significant gap in access across meal recipients can be observed. About 66% of students eligible for free and reduced-price meals—representing the low socioeconomic status students—are in disadvantage, and hence identified as vulnerable, with a group coverage below the overall coverage (77.7%). To ensure equitable coverage of education across low-income and high-income families, about 9% of available services would need to be reallocated. This disparity among the social groups is captured by a high D-index of 9.1 which generates the HOI of 70.58, the lowest among the considered circumstance groups. HOI must lie between 0 and 100 percent, since the HOI is lower than the coverage rate of the opportunity, and the difference between the two represents the "penalty" for an unequal distribution.

A moderate gap across the population of different race/ethnicity background is also perceived, suggesting that opportunities are unequally distributed. When considering each of the race/ethnic

groups, one vulnerable group can be observed: black (66.2%), whose share is below the overall coverage (77.7%). The share for hispanic children (75.5%) is close to the average. For whites and other race/ethnic groups, the coverage is higher than the overall coverage, suggesting disparities in the opportunities work in their favor. The D-index of 5.8 displays the share of total enrollments that are "misallocated", generating an HOI of 73.

Note that this approach has methodological shortcomings since multiple circumstance variables are related to each other. By computing the IOP one by one, it is overestimated to some extent due to double-counting; e.g., being low-income has a negative effect; being women has a negative effect and being a low-income woman is worse than the two effects summed up. To improve accuracy in the IOP index, information at a more disaggregated level is required. The analysis in the next section overcomes this limitation.

3.2. Opportunity Measures: To Get an Offer from a High-Quality School

Table 5 shows the model estimates for the opportunity to get an offer in the school of any quality (left) and a school of high-quality (right). Given a large dataset, equality of opportunity would imply that the access to high-quality education should be independently distributed of the circumstances [42]. In statistical terms, in an equal opportunity society, there is no statistically significant association between circumstances and important life outcomes. Note that in some cases the IOP is underestimated due to the omission of the interaction effects. Hence the estimated D-index is the lower bound of inequalities, and the estimated HOI is the upper bound.

For the admission to high-quality schools, student disability status, having a sibling in the school, being female and speaking the English language at home is not statistically significant in explaining the admission to SDHC magnet middle schools in 2015–2016. Non-significant coefficients and coefficients with the unexpected sign are kept in the estimation [8]. For both models (any-quality vs. high-quality), the geography variables (distance from home and student's home located in an urban area) are significant. A decrease of 5.6 in the log-odds of getting admission is expected when the applicant lives in an urban area—instead of a rural area—for a school of any quality, and a decrease of 4.4 for a school of high-quality.

Overall, in 27 out of 33 OECD countries including the US, the location of the family's residence and its proximity to the school is the principal criterion for assigning schools to students for lower and higher secondary schools [63]. In contrast, our analysis reveals that distance is not an important criterion for student assignment at magnet schools at SDHC. In fact, at SDHC magnet middle schools, for every additional mile in the distance from home to school, a 1.06 increase in the log-odds of getting the admission is expected, holding all other independent variables constant. The sign and magnitude of this coefficient are unexpected but clearly explained by the fact that magnet children are transported for free over large distances across the district.

Living in a place where the attendance area school is a Title I school and having a parent who is an employee at the school district are both statistically significant variables for the admission to schools of any and high quality. As explained before, at SDHC priority is given to families who reside in a public-school attendance area with high numbers of low-income students. This mechanism provides students living in poverty, who are in the greatest educational need of those services, with the extra educational supports they need to achieve academically. This mechanism might be used by the school district to overcome the deprived circumstance of the child given by his/her current place of residence.

Two differences are relevant between the estimates of any-quality vs. high-quality schools: First, if the student has a low socioeconomic status, the log-odds of getting an offer in a high-quality school are decreased by 5.29. Second, if the student's race/ethnicity is black, the log-odds of getting an offer in a high-quality school are decreased by 3.06 and if he/she is a latino student, the log-odds are increased by 2.40, both of them in comparison with the chances for white students, the reference category.

Table 5. Model estimates for the opportunity to get an offer to an SDHC magnet middle school.

Model Variables	School of Any Quality				School of High-Quality			
	Coef.	Robust Std. Error	z	P > z	Coef.	Robust Std. Error	z	P > z
The student qualifies for FRL	−0.1068	0.0928	−1.15	0.250	−0.4526	0.0855	−5.29	0.000
Student's race/ethnicity is black	−0.0058	0.1039	−0.06	0.955	−0.2914	0.0952	−3.06	0.002
Student's race/ethnicity is hispanic	0.3314	0.1327	2.50	0.012	0.2914	0.1213	2.40	0.016
Student's race/ethnicity is other race	0.1974	0.2030	0.97	0.331	0.1996	0.1819	1.10	0.273
The Student has a disability	−0.0120	0.0827	−0.14	0.885	0.0742	0.0758	0.98	0.327
Student is female	−0.1990	0.0781	−2.55	0.011	−0.0065	0.0715	−0.09	0.927
The student has a sibling	0.1273	0.0860	1.48	0.139	0.1296	0.0776	1.67	0.095
Student's parent is an employee	1.4379	0.2759	5.21	0.000	1.3297	0.2180	6.10	0.000
Student's home language is English	0.1902	0.1472	1.29	0.196	0.2296	0.1331	1.73	0.084
Student's assigned school is Title I	0.0983	0.0088	11.22	0.000	0.0727	0.0076	9.62	0.000
Distance from home to school	0.9206	0.2743	3.36	0.001	1.0612	0.2631	4.03	0.000
Student's home is located in an urban area	−0.0116	0.0021	−5.64	0.000	−0.0088	0.0020	−4.40	0.000
Constant	−0.7160	0.3420	−2.09	0.036	−1.0359	0.3212	−3.23	0.001
Model Statistics								
Log Likelihood	Ll	−1984.97			Ll	−2276.72		
Chi-square	chi2	205.93			chi2	258.87		
Akaike Information Criterion	Aic	3995.94			Aic	4579.43		
Bayesian Information Criterion	Bic	4076.83			Bic	4660.32		
Degree of Freedom	Df	13			Df	13		

Note: Coef.: Raw coefficient; z: z-score for test of b = 0; P > z: *p*-value for z-test; Std. Err: The standard errors associated with the coefficients. The significance is at the 95% confidence level.

The top part of Table 6 shows the measures of equality of opportunity for the admission to schools. The rate of overall coverage is affected by the quality component; while for any-quality schools it is close to 75%, the coverage rate lowers to 64% for high-quality schools. The D-index indicates the distance between the distribution of the opportunities and the distribution of the population across circumstance groups. The greater the variation, the higher the IOP.

Table 6. Inequality Measures and contribution of circumstances to IOP for the opportunity of getting an offer to an SDHC magnet middle school.

	School of Any Quality		School of High-Quality	
	Values	**Std. Error**	**Values**	**Std. Error**
Inequality Measures				
Coverage (C)	74.4561	0.6906	64.1418	0.7540
Dissimilarity Index (D)	5.9482	1.5901	8.5719	2.0364
Human Opportunity Index (HOI)	70.0273	0.8179	58.6436	0.8565
Shapley Decomposition of D-index				
The student qualifies for FRL	5.53		23.15	
Student's race/ethnicity is black	5.81		15.74	
Student's race/ethnicity is hispanic	3.86		2.88	
Student's race/ethnicity is other race	0.78		1.06	
The student has a disability	1.65		4.00	
The student is female	5.56		0.50	
The student has a sibling	1.79		1.61	
Student's parent is an employee	10.31		9.95	
Student's home language is English	0.90		0.79	
Student's assigned school is a Title-I school	56.84		34.92	
Distance from home to school	1.05		1.61	
Student's home is located in an urban area	5.93		3.81	

The D-index, similarly, reveals more disparities in the distribution of the opportunities when the quality of the school is considered. Quantitatively, the D-index reveals that in SDHC 8.57% of the opportunities to access schools of high-quality would need to be rearranged to achieve equality of opportunity. In contrast, 5.94% of opportunities would need to be rearranged for schools of any quality. The HOI measure summarizes the opportunities for education, both in coverage and in the distribution among the groups, arising to 70.0 for admission to a school of any quality, but lowering to 58.6 for a school of high-quality.

3.3. Determinants of Inequality: To Get an Offer from a High-Quality School

The contributions of circumstances to the IOP is presented in the bottom part of Table 6. Contributions represent the share of the D-index that is explained for each one of the circumstances. All the contributions add up to 100. Living in an attendance area where the school has high numbers of economically disadvantaged students (Title I school) was the most important factor affecting equality of opportunity in getting an offer to a middle school, which explains the 56% of the inequality measure for high-quality schools, and 35% for any quality schools.

The second factor was having a parent who is an employee at the school district, explaining about 10% of the measure. After that, the other two most important contributors to inequality in access are the SES level of the student (qualifying for FRL) (23%) and being of black race/ethnicity (15%), important only for high-quality schools.

4. Discussion

Goal 4 in the 2030 agenda for sustainable development [1] aims at ensuring inclusive and equitable quality education for all. The education 2030 framework for action recognizes the important role of education as the main driver of development [64]. It stresses the need to address all forms of exclusion

and marginalization, to serve all learners, regardless of their context and personal characteristics, including "those from the poorest households, ethnic and linguistic minorities, indigenous people, and persons with special needs and disabilities." [64,65].

Equity issues constitute a major challenge in the achievement of the education goal [66]. Equality of educational opportunity specifies a fair way to distribute the available places, by giving all people the same chances for schooling. Governments are held responsible for designing a policy that equalizes educational opportunities. According to Dabalen et al. [8], a policy aiming at equitable access would require progress towards two objectives: first, expanding coverage, by ensuring that as many people as possible get the opportunities; and second, by allocating new opportunities first to the vulnerable population, those who are at a disadvantage due to their circumstances.

Using data from a large public urban school district in Florida, this work measures the opportunity to get access to high-quality education, i.e., how closely an existing admission policy matches the equality of opportunity principle. Two indicators of access to lower secondary education in magnet schools are assessed: whether the child is enrolled in a school; and whether the child has been admitted to a school. Since all kids that currently study in an SDHC magnet school had to go through the admission process at a previous point in time, enrollment reflects the long-term effect of the application of the admission policy in the past.

The coverage rate for the enrollment in SDHC magnet lower secondary high-quality schools is about 78%. Worldwide the adjusted net enrollment rates reached 91% for primary education, 84% for lower secondary education and 63% for upper secondary education in 2017 [66]. SDHC's access rate is close to the worldwide rate for children of the same age (only 6 points' difference), which is low considering that we accounted only for high-quality schools.

The D-index and the HOI measures indicate that all the students currently enrolled at SDHC magnet middle schools do not have the same opportunities to be well educated. The enrollment configuration at SDHC exposes that students with high socioeconomic status have a higher opportunity to get a high-quality education. Access is also distributed unevenly across children of different race/ethnicity: black children's share of the opportunity is below the overall coverage. Consistent with our findings, Burgess and Briggs [67] find that students from low-income families have around half the chance of attending high performing schools, compared to those from non-low-income families. This coverage rate is similar for public students at the middle level at SDHC (53.5%) but significantly lower than the rate for magnet middle students in the district (77.7%).

The allocation mechanism is important and determines how equal a society is in terms of an opportunity. Popular high performing schools are likely to be oversubscribed and school districts need to find ways to ensure an even social mix. One policy for the allocation of new educational opportunities, for instance, would be running a lottery where all kids have an equal chance of getting a place. A lottery mechanism is a way to achieve fairness in the assignment process [68]. Several school districts had examined the use of lotteries to allocate spots when oversubscribed [69–71].

If a person is a victim of bad circumstances, such as a displacement situation, or disability, then his/her opportunities would need to be relieved. In Roemer's viewpoint, individuals at disadvantage should receive more resources [6]. In such cases, a policy supporting preferential admissions for students of low socioeconomic status (or other criteria that identify kids in disadvantage) might be considered. SDHC is exploring weighted random allocation as a method for distributing school places fairly and for promoting a more even allocation of educational opportunities. When using weighted lotteries, some have slightly more chances than others, leveling the playing field for those in disadvantage. A measure to assess the level of equality in the allocation mechanism is needed.

The most statistically significant variables for the admission to high-quality schools at SDHC reveals efforts from the school district towards the equality goal. SDHC seems to be determined to help underprivileged children alleviate the personal circumstances, by assigning priority to those in disadvantage from their circumstances, such as living in poverty or residing in a neighborhood school with poor academic performance. This finding can be explained by the fact that school districts that

accept Title I funds must offer school choice to students in public schools identified for improvement so that no student is trapped in an underperforming school [72]. Often schools implement this requirement allowing students at lagging schools to attend other schools in the district and giving priority to low achieving and low-income students.

Nevertheless, the socioeconomic status and the student's race/ethnicity seem to influence the chances of receiving an offer in high-quality schools, suggesting that those students might be at a disadvantage due to their personal or family circumstances. This result is consistent with our decomposition analysis that evidences that circumstances, the characteristics of the assigned area school, the socioeconomic status and students' race/ethnicity are the most significant contributors to IOP. Previous studies in Latin America reveal that the characteristics of the home (parents' education, the composition of the family) and its income account for the majority of inequalities in access to educational opportunities [38].

There are several methods for measuring equality, each with advantages and disadvantages, that can lead to different conclusions about the degree of inequality [17,73]. The analysis of IOP for access to lower secondary education of high quality performed in this study complements traditional inequality measures proposed for the SDG, such as PI. The parity index currently used in the SDG provides the relative magnitude of the disparity. Both, PI and the HOI, are indicators with a simple and clear interpretation and can be computed in a very transparent way. However, the HOI adds more insights than PI.

Three main contributions of HOI stand out: first, the HOI is a scalar synthetic measure of the gaps in access to basic services in multiple circumstances; in contrast, PI needs to be measured and analyzed for each circumstance independently; second, HOI summarizes the opportunities for education, both in coverage and in the distribution among the groups; in contrast, PI measures the relative access to education of one group versus the other group; there might be parity in access which yet masks other important inequalities, for instance when there are low levels of access for both groups; third, PI cannot easily be decomposed to show the sources of inequality; in contrast, the decomposition of the D-index allows the user to explore the marginal/average contribution of each circumstance to overall IOP.

An important caveat to interpreting our results is that we are only able to evaluate the influence of the children's circumstances in the admission from the set of applicants that were considered by the schools, i.e., those families who chose to apply to the lottery, but our findings may not generalize to other students. School choice is exercised in different ways by families. Better-educated parents make better-informed choices [63]. Previous studies have found that applicants take into consideration their social circumstances when stating their preferences for specialty schools [74]. SDHC does not have poverty level or race/ethnicity in the criteria for admission, yet both the criteria at the time of the decision on admission show relevance. Certain criteria might be important for the parents and not for the schools. Our analysis cannot isolate this effect.

While our study provides an important examination of how children circumstances influence the chances of school admission/enrollment, it involves some evident limitations. For instance, our analysis is a relatively static cross-sectional study in nature, allowing to compare many different variables at the same time, for a specific geographic area, for one academic year. Arguably, a superior assessment would consist of a longitudinal analysis to determine whether changes in the predictor variables predict changes in the characteristics of the students admitted to several school districts in a larger region, and over time. However, different school districts have different admission policies, and several observations of the same students over a period of time would be rare to find, due to the features of the data. It is our hope that, for the sake of transparency, as more admission data continues to be opened to researchers for more geographic areas over the next years, additional analysis can be conducted to better assess the dynamic aspects of the relationships examined by the present study.

5. Conclusions

Prior research on educational opportunities measures how far a given distribution of individual outcomes is from equal opportunity, capturing different aspects of education, such as participation, attainment, and achievement. The aim of this paper is complementary to those contributions. Given the fact that the admission process is the earliest step in the education process, the main contribution of this study is in the assessment of the empirical distribution of the provision of opportunities for the admission to schools. Clear rules and priorities are set to ensure that the school allocation is fair: children with dissimilar backgrounds should all have equal access to good schools. This study attempts to measure the amount of "fairness" in such an initial allocation of scarce educational resources, from the beginning of the education process.

Our results indicate that the HOI metrics and the distribution of opportunities among different groups of children allow the identification and analysis of potential inequalities in access to education. HOI is capable of systematically monitoring and examining existing admission policy and identify potential inequality problems. Furthermore, the analysis of the contribution of each circumstance group can reveal admission criteria that have the potential to harm the educational opportunities for children.

By analyzing several school records of admission data, an equality of educational opportunity profile for a particular region produces actionable understandings that school district's policymakers can use to evaluate current admission policy, plan out its enrollment goals, make predictions of student enrollment, and optimize their resource allocation. This assessment should provide valuable insights into the capability of the indicators to reveal where policy intervention is necessary and supply points of view on how policy can be improved. In the future, these insights might help guide the design, development, and implementation of an effective public policy aimed at equalizing opportunity for access to high-quality education.

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