



University of Tehran
Faculty of Economics

**Estimation of Inequality of Opportunities
in Education;
Evidence from PILRS 2016 & 2021**

Author:
Siavash Delavar

Supervisor:
Dr. Atiyeh Vahidmanesh

September 2024

Abstract

Assessing educational equity and identifying barriers to students' access to it hold critical importance. Understanding the factors contributing to educational inequality, particularly those beyond the control of students, is a fundamental question in educational policymaking. The effects of such factors can be analyzed within the framework of the theory of inequality of opportunity. This approach seeks to measure the influence of variables such as gender, ethnicity, place of residence, and family conditions on students' educational outcomes. The significance of this analysis lies in its ability to inform policymakers about the key contributors to disparities among students, thereby guiding effective decision-making.

In this study, using data from the Progress in International Reading Literacy Study (PIRLS), the inequality of educational opportunities among Iranian students is quantitatively assessed. A specific index was employed to measure the extent of inequality of opportunity in education, which was calculated for the years 2016 and 2021. The Shapley decomposition method was applied to evaluate the contribution of various factors to this inequality index. The findings indicate a slight increase in the inequality of educational opportunities over the five-year period under study. Among the examined factors, the cultural environment at home, students' place of residence, ethnicity, and parental education emerged as the most significant contributors to educational opportunity disparities in reading and comprehension skills in the country.

Keywords: Education, Inequality of Opportunity, Educational Equity

1 Introduction

With the emergence of thinkers such as Hobbes, Locke, and Rousseau in the 17th century, and their ideas within the framework of social contract theory, theorization on justice entered a new phase. In the 19th century, Karl Marx critically examined the theories of justice that came before him, focusing on the economic and class structures of societies. In his influential work *Capital*, Marx criticized the capitalist economic system for enabling the exploitation and oppression of the working class by the property-owning class. He argued that this exploitation posed a serious threat to justice in society. Marx believed that true justice could only be achieved by abolishing private ownership, which would eliminate economic classes. In this envisioned classless society, the distribution of economic resources would not depend on individuals' contributions to the economy but rather on their needs.

In the second half of the 20th century, John Rawls emerged as one of the most prominent theorists in social sciences and philosophy with the articulation of his distributive justice theory. In his influential book, *A Theory of Justice*, Rawls sought to present a precise formulation of his views. He introduced a hypothetical scenario in which individuals, behind a "veil of ignorance," evaluate their position and status within society. In this hypothetical situation, individuals have no prior knowledge of their social or economic position or personal characteristics. This lack of information compels them, in the role of societal architects, to choose a structure that is just and fair for all.

Rawls argued that under these conditions, rational individuals would make two primary choices. First, all members of society should have equal access to fundamental rights, such as freedom of speech and voting rights. Second, while social and economic inequalities may be permissible, these inequalities must be structured to benefit the least advantaged groups. According to Rawls, justice in society must operate within a framework that acknowledges interpersonal differences but prioritizes fairness and equity for everyone, particularly the less privileged (Rawls, 1971).

Rawls's ideas had a profound impact on discussions surrounding justice. His concepts played a pivotal role in shaping theoretical perspectives on issues such as welfare policies, resource distribution, and the role of governments and institutions in ensuring equitable opportunities, allowing all members of society—especially the disadvantaged—to achieve their potential fairly.

The new perspective on inequality, championed by Rawls, became the foundation for subsequent research. Sen (1979) emphasized the importance of creating an environment conducive to the flourishing of individual capabilities rather than merely focusing on resource distribution. He argued that the priority should be to establish a supportive framework and provide individuals with the freedom to grow, acknowledging their diverse needs and conditions.

Dworkin (1981a, 1981b) introduced the idea that individuals are responsible for their personal decisions. As such, inequalities arising from individual choices are acceptable, while those caused by circumstances beyond an individual's control should be minimized. In his works, Dworkin presented two approaches that responded to Rawls's theories: equality of resources and equality of welfare. He distinguished between these to clarify the role of individual responsibility in generating inequality. According to Dworkin, the concept of equality of welfare neglects individual responsibility and choice, resulting in an uneven allocation of resources, which he deemed incompatible with the principle of fairness. Instead, Dworkin advocated for equality of resources, asserting that only those inequalities originating from factors beyond individuals' control should be addressed. This approach recognizes individuality and ensures that all members of society start from an equal baseline of resources, allowing their social and economic positions to reflect personal choices and inherent capacities.

By distinguishing between inequalities based on their origins, Dworkin contributed to the theoretical development of research on equality of opportunity. In summary, as long as resources and opportunities (referred to as "circumstances") are equitably distributed, the ultimate outcomes of individuals (e.g., income, education) hold less significance in the context of social justice. Arneson (1996) also proposed the concept of equal access to welfare, arguing that despite differences in choices and circumstances, individuals should be able to achieve a level of welfare they consider satisfactory.

Inequality of Opportunity (IOP) in Economics: Key Challenges and Importance

In the context of inequality of opportunity (IOP) in economics, two primary challenges arise. The first is how to measure such inequalities. Unlike income inequality or similar metrics, calculating IOP involves significant difficulties, such as data limitations. These challenges often make it difficult to quantify IOP in a reliable and systematic manner.

Consequently, many studies on inequality have instead focused on estimating proxies like wage inequality rather than directly addressing IOP. The second challenge relates to public policy design aimed at reducing IOP and ensuring equitable access to opportunities for all members of society. Policymakers must determine how to create a “level playing field” where individuals can access equal opportunities regardless of their circumstances.

The importance of addressing IOP and distinguishing it from final outcomes, such as income or educational attainment, can be highlighted in three ways. First, understanding IOP helps identify the root causes and processes that lead to income inequality, allowing targeted efforts to address them. Second, research shows that the overall performance of economies is more closely related to economic opportunity inequalities than income disparities. For instance, Bourguignon et al. (2007) and the World Bank (2006) highlight that persistent and significant IOP can create "inequality traps," hindering long-term economic growth and development. Third, societal attitudes toward redistributive policies are heavily influenced by perceptions of the origins of inequality. Research by Alesina et al. (2005) shows that people are generally less sensitive to inequalities arising from individual effort than those stemming from unequal opportunities. This underscores the importance of raising public awareness about the roots of inequality, which can facilitate government efforts to implement redistributive policies effectively.

John Roemer is one of the prominent scholars who has made significant contributions to measuring inequality of opportunity (IOP). In his book *Equality of Opportunity* (1998), Roemer developed a framework for the formulation and quantification of IOP. According to Roemer, the factors determining an individual's success should be divided into two categories:

1. **Circumstances:** These are exogenous factors over which individuals have no control, such as gender, ethnicity, place of birth, and family background.
2. **Effort:** This refers to the set of factors that, while influencing individual success, are under the person's control to some extent. The quantity and quality of these factors are shaped, at least partially, by individual decisions. Roemer uses "effort" as a shorthand for these factors but emphasizes that it also reflects choices and luck.

Based on this theoretical framework, Roemer defines equality of opportunity as a policy ensuring that individuals with the same degree of effort achieve comparable outcomes, regardless of their circumstances. He proposed grouping individuals by their

circumstances, such that each group consists of individuals with identical circumstances but potentially varying levels of effort. Equality of opportunity, in this context, ensures that the outcomes of individuals with equal effort levels across different groups are equivalent. Mathematically, if C represents the set of circumstances and y denotes the outcome in a specific domain (e.g., education, income, health), the condition for equality of opportunity is expressed as:

$$f(y|C)=f(y)$$

In this analysis, greater dependence of the distribution of y on C indicates a worse state of equality of opportunity. For complete equality of opportunity, the probability distribution of y must be independent of C . However, Roemer acknowledged that in practice, achieving ideal conditions is rarely possible (Roemer, 1998).

Building on John Roemer's theoretical framework, subsequent researchers employed various approaches to calculate indices of inequality of opportunity (IOP). Bourguignon et al. (2007) utilized a parametric method to evaluate IOP in Brazil, assessing the contribution of each circumstance to wage inequality. They estimated income as a function of two factors—circumstances and individual effort—and examined the impact of five specific circumstances: ethnicity, parental education, place of birth, and father's occupation on wage disparities. Lefranc et al. (2008) used a non-parametric stochastic dominance approach to compare income inequality and IOP across nine developed countries in the 1990s. Their findings revealed a strong correlation between IOP and income inequality in these nations. Checchi and Peragine (2010) employed a non-parametric approach similar to Roemer's conceptualization. They first grouped individuals by similar circumstances, with between-group income distributions reflecting IOP. Then, they categorized individuals based on their levels of effort, where within-group income distributions captured inequality attributable to effort. By comparing and analyzing these results, they estimated IOP in Italy using income data. Ferreira and Gignoux (2011) calculated IOP in six South American countries using both parametric and non-parametric methods. In another study, these researchers used data from the international PISA assessments to measure educational IOP across 57 countries. Employing a parametric approach, they developed an index to quantify educational IOP, considering circumstances such as gender, parental education, and family economic status as determinants of students' outcomes (Ferreira and Gignoux, 2014).

Inequality of Opportunity (IOP) in Education

Education is a vital tool for addressing economic and social inequalities, and educational inequality remains one of the most significant manifestations of inequality in both developed and developing countries. The need to examine and study educational inequality becomes even more critical when considering the substantial role educational outcomes play in individuals' growth and success in adulthood. Academic achievements also serve as strong predictors of future income levels, as demonstrated by research from Blau et al. (2005) and Bedard et al. (2003), which highlights the correlation between disparities in educational outcomes and income inequality both within the United States (over time) and across countries. Educational systems must strive to create conditions conducive to students' academic growth by utilizing all available resources effectively. Equitable distribution of educational resources is essential in this regard. Efforts should be made to ensure that students' educational outcomes are influenced primarily by their effort and abilities, rather than by social, economic, or cultural conditions beyond their control. While studies such as those by Hanushek and Woessmann (2008, 2012) show that the quality of education is a key determinant of long-term economic growth, Marrero and Rodriguez (2009) explored the role of equal educational opportunities in driving national economic development. Furthermore, education is closely linked to various development indicators, such as public health and political participation, which are crucial for fostering democracy in societies. All these factors underscore the importance of understanding and addressing inequalities and deficiencies in the education sector.

For the reasons mentioned earlier, educational equity holds significant importance for policymakers. Decision-makers in the education sector are keen to identify the conditions and variables that most strongly affect students' academic performance. However, there is less consensus on how to measure inequality of educational opportunity and how to quantify it effectively. Due to data limitations, early research primarily focused on measuring disparities in access to education across countries rather than inequalities in educational opportunities. For instance, Thomas et al. (2001) analyzed data on years of schooling from 85 countries between 1960 and 1990, highlighting trends in educational access. Similarly, Castelló and Doménech (2002) examined data from 108 countries, demonstrating that inequality in access to education negatively affects economic growth. Morrison et al. (2007) also investigated the relationship between disparities in years of schooling and economic growth over a long-term period in many countries around the world.

The concept of inequality of opportunity (IOP) introduces a new dimension to the study of inequality in education. It emphasizes the impact of factors and circumstances beyond students' control—such as gender, ethnicity, and family background—on the expansion of educational disparities. From a policymaker's perspective, identifying which of these factors has the greatest influence on students' educational outcomes is crucial. Such knowledge enables the development and implementation of targeted policies to mitigate the effects of these circumstances on students' success and foster equal educational opportunities.

In recent years, numerous school-based survey projects have been conducted to assess the cognitive abilities of students across different countries. These projects often collect additional data on students' parents and schools—typically through questionnaires. Examples of such international assessments include TIMSS, PISA, and PIRLS, the latter targeting younger students. These assessments are organized by international institutions and organizations. The rich datasets generated by these assessments have supported numerous studies, some of which focus specifically on inequality of educational opportunity. For instance, Ferreira and Gignoux (2010, 2011) conducted separate studies on inequality of educational opportunity in Turkey and Latin America. Similarly, Gamboa and Waltenberg (2012) focused on Latin America, while Salehi-Isfahani et al. (2014) examined countries in the Middle East and North Africa. Hashemi et al. (2015) utilized TIMSS data, and Peragine et al. (2015) used PISA data to analyze inequality of educational opportunity in Arab countries. Lasso et al. (2019) investigated inequality of educational opportunity in several European countries using PISA data, and Marrero et al. (2023) evaluated inequality of educational opportunity in Western Europe using 2018 PISA data.

2 Measuring of Inequality of Opportunity

Viewing justice through the lens of inequality of opportunity (IOP) offers a fresh perspective on the concept of justice. As previously mentioned, understanding the factors that significantly influence students' academic achievements is crucial. This study focuses on examining educational inequality of opportunity in Iran, utilizing data from the fourth (2016) and fifth (2021) cycles of the PIRLS international assessment. The primary objective is to identify the barriers that prevent students from reaching their full academic potential. The central idea behind IOP is to ensure that all individuals have equal opportunities to thrive. As Dworkin emphasized, societal resources should be allocated fairly through policy interventions, addressing inequalities that stem from circumstances beyond individuals' control. Within this framework, all individuals are envisioned to start on an equal footing, enabling them to pursue growth and fulfill their potential.

As previously mentioned, Roemer's efforts to provide a moral and philosophical interpretation of equality of opportunity (EOP) opened new avenues for subsequent researchers. His work significantly advanced the quantitative measurement of EOP. At the core of his theory, Roemer argued that opportunities in a society are equal when the distribution of outcomes (in a given domain) is independent of circumstances beyond individuals' control. In other words, equality of opportunity is achieved when individual success or failure is determined solely by personal characteristics. These characteristics include not only effort but also individual abilities and personal choices. Roemer's interpretation of EOP can be mathematically expressed as follows:

$$f(y | C) = f(y) \quad (1)$$

In this equation, y represents students' outcomes (in this case, final test scores), and C refers to circumstances beyond their control. The factors considered as circumstances in any research depend on the dataset being used. In the present study, circumstances are categorized into four main groups:

1. **Student-Level Circumstances:** Gender, attendance in preschool or kindergarten (after the age of three).
2. **Parental and Household-Level Circumstances:** Mother's level of education, father's level of education, number of books at home, frequency of speaking the test language at home, parental involvement in early education activities (e.g.,

reading stories or singing songs for the child), family wealth, access to a study desk, having a personal room, access to the internet, and access to a computer at home.

3. **Teacher and Classroom-Level Circumstances:** Teacher's gender, teacher's educational level, years of teaching experience, and class size.
4. **School and Locality-Level Circumstances:** School location (urban or rural and population density), proportion of students from economically privileged families at the school, and proportion of students from economically disadvantaged families at the school.

To compute the inequality of opportunity index based on Roemer's framework within the domain under study, two approaches can be employed: the ex-ante approach and the ex-post approach. It is important to note that due to technical limitations, these two approaches do not necessarily yield identical results.

Ex-post Approach: In this approach to analyzing inequality of opportunity, individuals are grouped based on their level of effort. Within-group equality of opportunity is achieved when all individuals in a group attain the same outcome. Naturally, the greater the inequality within groups, the higher the inequality of opportunity. This approach, utilized by Checchi and Peragine (2005, 2010), is conceptually closer to Roemer's theoretical framework. However, its significant limitation lies in its requirement for large datasets to accurately distribute individuals with varying and continuous levels of effort into distinct groups.

Ex-ante Approach: In this approach, individuals are categorized based on their circumstances, grouping those with identical circumstances together. Formally, let the total sample be denoted as S , the vector of circumstances as C , the set of categories as Γ , and each category as T . Then: $\Gamma = \{T_1, T_2, \dots, T_k\}$, such that $T_1 \cup T_2 \cup \dots \cup T_k = S$ and $T_i \cap T_j = \emptyset, \forall i, j$, and $C_i = C_j, \forall i, j \mid i \in T_k, j \in T_k, \forall k$. The closer the average outcomes across different categories, the greater the equality of educational opportunity. In other words, the variance in average scores across categories reflects the extent of inequality in educational opportunity (Van de Gaer, 1995).

In this study, we adopt an ex-ante approach with a parametric method to examine educational inequality of opportunity. The parametric method typically involves a regression that captures the relationship between outcomes and circumstances (Dardanoni et al., 2006; Bourguignon et al., 2007), expressed as follows:

$$yi = Ci\beta + \epsilon i \quad (2)$$

In this equation, C represents the set of circumstances and the constant coefficient, while ϵi accounts for unobserved factors that influence students' outcomes. This factor reflects elements such as effort and luck, and are assumed to have a random distribution independent of C. Equation (2) is a simplified representation of the influence of circumstances on students' outcomes, as circumstances can indirectly affect outcomes through their influence on effort.

The set of circumstances in this study consists of 19 variables. Seventeen of these were derived directly from individual items in four questionnaires, while two variables—household wealth and parental involvement in early education—were constructed by combining multiple questionnaire items. Household wealth was derived from four questions in the student questionnaire, and parental involvement was extracted from 16 questions in the parent questionnaire.

Principal Component Analysis (PCA)

Principal Component Analysis (PCA), a dimension-reduction technique, was used to extract these two variables. PCA is a statistical method based on linear algebra for reducing the dimensionality of data analysis. It transforms correlated variables into a smaller number of uncorrelated components by projecting them onto new orthogonal directions. The method involves calculating the covariance matrix of the original variables, finding its eigenvectors (the principal directions), and projecting the variables onto these directions to form the principal components. Each principal component is a linear combination of the original variables, and its corresponding eigenvalue indicates the variance explained by that component. Larger eigenvalues represent higher variance along that principal direction. By ordering the eigenvalues from largest to smallest, we can decide how many principal components to retain for the analysis.

For household wealth, derived from four questions, three principal components explaining approximately 80% of the variance were retained. Similarly, for parental involvement in early education, seven principal components explaining about 70% of the variance were used. As a result, the four variables related to household wealth were reduced to three, and the 16 variables on parental involvement were reduced to seven. The eigenvalues

corresponding to the principal components for wealth variables in the 2016 and 2021 data are presented in the following charts and tables.

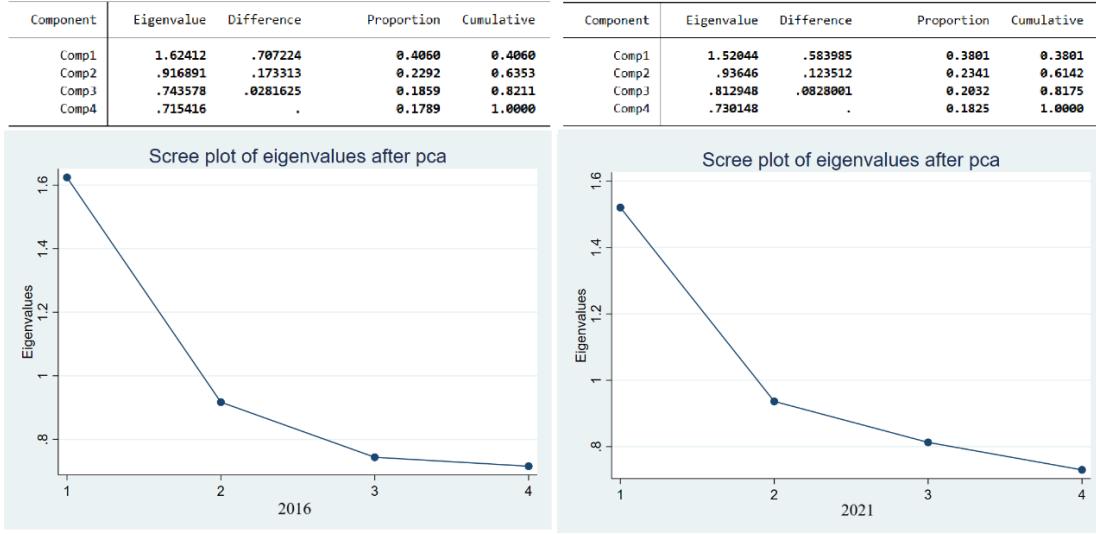


Figure 1 Eigenvalues of Principal Components for Wealth Variables in the 2016 and 2021 Data

A straightforward method to measure inequality of opportunity is to compare the dispersion of the fitted score distribution, derived from Equation (2), with the actual score distribution of students:

$$\tilde{z}_i = \mathcal{C}_i \hat{\beta}. \quad (3)$$

Naturally, the dispersion of \tilde{z}_i , which represents the effect of circumstances on students' scores, is less than the dispersion of their actual scores(y_i). Therefore, the ratio of the dispersions of these two variables can serve as an index for measuring educational inequality of opportunity:

$$\theta_d = \frac{I(\tilde{z}_i)}{I(y_i)}. \quad (4)$$

The subscript d indicates that this index measures inequality of opportunity directly, without considering individual effort.

In the parametric method, an alternative approach involves calculating the inequality index using a standardized synthetic distribution. In this approach, all circumstances are fixed at their mean values. Thus, the dispersion in this synthetic distribution reflects factors such as effort, luck, and unobserved variables. To create this new distribution of student scores, the constants and residuals from Equation (2) are utilized:

$$\tilde{y}_i = \bar{C}\hat{\beta} + \hat{\varepsilon}_i. \quad (5)$$

Since the circumstances in this equation are held constant at their mean values, the dispersion of \tilde{y}_i can be attributed to students' effort, luck, and unobserved factors. Based on this approach, the inequality of opportunity index is calculated as follows:

$$\theta_r = 1 - \frac{I(\tilde{y}_i)}{I(y_i)}. \quad (6)$$

The subscript r indicates that this index is derived using residuals. Given the significant number of variables that could potentially reduce estimation accuracy, the residual method is used to compute the inequality of opportunity index in this study.

In selecting an appropriate inequality index $I(\cdot)$ to measure the dispersion of student scores, various measures of dispersion can be employed. Ferreira and Gignoux (2014), due to the simplicity of variance, utilized this index in their study. Accordingly, in their method, educational inequality of opportunity is equivalent to the R^2 statistic in the regression model represented by Equation (2).

Another inequality index that can be employed is the Generalized Entropy (GE) index. First used by Shorrocks (1984) for measuring inequality, this index possesses several properties that justify its application in the present analysis. These properties include:

1. **Anonymity:** Insensitivity to the ordering of individuals in the sample.
2. **Population Invariance:** Independence from the sample size (population principle).
3. **Transfer Sensitivity:** Responsiveness to redistributions, ensuring proportional changes (transfer principle).
4. **Scale Invariance:** Insensitivity to changes in measurement scale.
5. **Additivity:** A unique property of the GE family, which allows total inequality to be expressed as the weighted sum of within-group and between-group inequalities.

The additivity property implies that if the sample is divided into subgroups, the total inequality can be decomposed into within-group and between-group components. This ensures that when comparing inequality of opportunity across countries in a specific year, the ex-post and ex-ante approaches yield consistent rankings of countries based on their inequality levels.

The GE index is calculated using the following formula:

$$GE(\alpha) = \frac{\alpha}{\alpha(\alpha - 1)} \frac{1}{n} \sum_{i=1}^n \left(\left(\frac{y_i}{\bar{y}} \right)^\alpha - 1 \right) \quad (7)$$

In this equation, α represents the order of the GE index. Due to the specific characteristics of the PIRLS dataset, particularly the emphasis on high scores in measuring inequality, this study employs GE(2), consistent with Salehi-Isfahani et al. (2014). Additionally, R^2 results are reported for comparison.

It is important to note that the estimated inequality of opportunity index represents a **lower bound estimate**. This limitation arises for two reasons:

1. The number of circumstances affecting a student's success is essentially infinite, making it impossible to account for all contributing factors.
2. The PIRLS dataset provides only a limited set of circumstances that can be extracted and included in the analysis.

Just as the influence of explanatory variables on the dependent variable in a regression equation is significant, their contribution to the dispersion of the dependent variable also holds considerable importance. This is particularly relevant in the present study, where inequality of educational opportunity is assessed by evaluating the dispersion of students' scores. One advantage of the parametric method is its ability to quantify the contribution of each explanatory variable to the dispersion and inequality of the dependent variable.

The Shapley decomposition method, first introduced by Shapley (1953) to solve allocation problems in cooperative game theory, can be utilized to evaluate the individual or group-level impact of explanatory variables on inequality of opportunity. In this method, inequality in the dependent variable is measured for all permutations of the explanatory variables, and the average marginal contribution of each explanatory variable to the inequality is calculated. The resulting value indicates the relative influence of that variable on the inequality of the dependent variable compared to other explanatory variables. Two key advantages of this method are its **path independence** and its **additivity property**.

In this study, the Shapley decomposition method is employed. The process involves categorizing circumstances into distinct groups and then assessing the contribution of each group to educational inequality of opportunity. Efforts were made to group circumstances

with the highest conceptual similarity together. As a result, ten groups of circumstances were created, described as follows:

1. **Student Gender:** Comprising only the variable related to the student's gender.
2. **Parental Education:** Including the variables for father's and mother's education from the parent questionnaire.
3. **Ethnicity:** Represented by the variable measuring the extent of the student's use of the test language at home.
4. **Student Residence:** Represented by the variable indicating the school's location (in terms of population density and rural/urban classification).
5. **Cultural Environment of the Home:** Including variables such as the number of books at home, and access to a computer, study desk, internet, and a private room.
6. **Kindergarten Attendance:** Including the variable for attending or not attending kindergarten (after age three).
7. **Household Wealth:** Comprising wealth-related variables derived using Principal Component Analysis (PCA).
8. **Teacher Characteristics:** Including variables for teacher gender, education level, and years of experience.
9. **School Characteristics:** Including variables for class size, the proportion of economically advantaged students in the school, and the proportion of economically disadvantaged students in the school.
10. **Parental Engagement:** Comprising variables related to the level of parental engagement in pre-school education (e.g., reading stories and singing songs to the child), also derived using PCA.

3 Data

The Progress in International Reading Literacy Study (PIRLS) is a global assessment of reading comprehension skills among fourth-grade students (approximately 10 years old), conducted by the International Association for the Evaluation of Educational Achievement (IEA). Since its inception in 2001, PIRLS has been held every five years. The primary objective of this study is to evaluate students' literacy skills and their ability to comprehend literary texts. Approximately 60 countries participate in this international assessment.

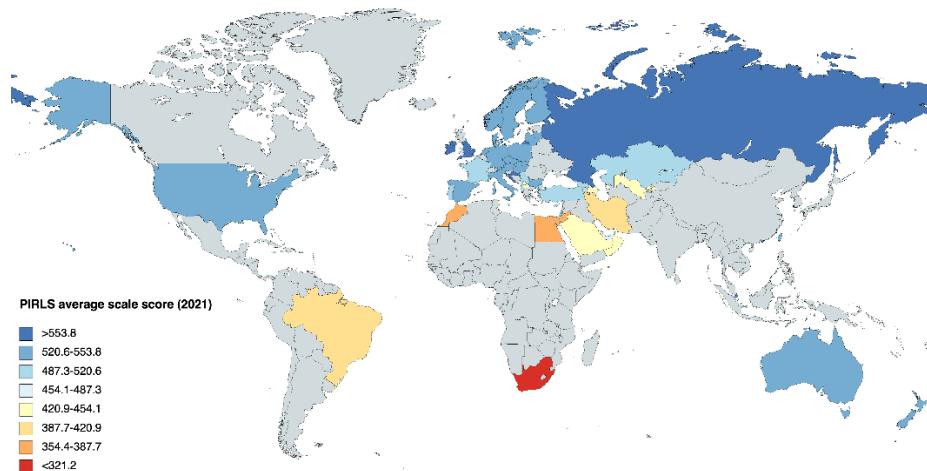


Figure 2 Participating Countries and the Average Scores of Their Students in the PIRLS 2021 Assessment

The reason for targeting fourth-grade students in this assessment is that, at this age, students acquire the foundational skills necessary for academic progression. The design and translation of the test questions are conducted with the assistance of local collaborators in participating countries. The test consists of a booklet in which each student is presented with two texts, followed by questions related to those texts. In addition to the question booklet, four questionnaires are distributed to students, parents, teachers, and school administrators.

- 1. Parent Questionnaire:** Includes questions about the student's early reading and writing habits, parental involvement in literacy activities before the child starts school, parents' reading habits and attitudes, home-school interaction, and the family's socio-economic status.

- 2. Student Questionnaire:** Includes questions about the student's prior educational experiences, attitudes toward reading and writing, study habits outside school, and access to and use of computers and reading materials at home.
- 3. Teacher Questionnaire:** Includes questions about the characteristics of the students' classroom, the teacher's instructional activities, educational resources within the classroom, methods of student assessment during the school year, and the teacher's education level and training courses completed.
- 4. School Administrator Questionnaire:** Includes questions about school enrollment and characteristics, educational facilities, school-parent interaction, and the school's environment and location.

In the sampling process, the target population includes all fourth-grade students, and sample selection in each country is conducted in two stages with the participation of local experts. In the first stage, schools are randomly selected. In the second stage, one or more classes are randomly chosen from the selected schools. To ensure that the sample reflects the diversity of the target population, schools are stratified based on factors such as geographical location, gender (boys' or girls' schools), and type (public or private). Although the aim is to include all fourth-grade students in each country, exceptions are made at both the school and student levels. Schools are excluded if they meet any of the following criteria: they are in remote locations, have fewer than five fourth-grade students, or use curricula significantly different from those of other schools in the country. Excluded students include those with physical or mental disabilities and students who are not proficient in the country's official language. However, the total number of excluded students at both levels should not exceed 5% of the country's fourth-grade population. In the case of Iran, this proportion is less than 3%.

Table 1 Statistical Summary of the Iran Sample

	Population		Sample			
	Number of Schools	Number of Students	Number of Schools	Number of Students	Gender	
					Girls	Boys
2016	36817	1120197	271	8766	47%	53%
2021	43697	1348842	218	5962	46%	54%

The PIRLS assessment is designed to effectively measure trends in the reading comprehension abilities of students across different countries over time. The results of this test can also be used to compare student performance between countries. Iran's student

performance, based on the scores obtained, does not rank favorably compared to other participating countries. The table below displays the scores of Iranian students. It is worth noting that the aggregation method for PIRLS results is standardized, with a global average score of 500 and a standard deviation of 100.

Table 2 Statistical Summary of Achieved Scores

	Total		Girls		Boys	
	Mean Score	Standard Deviation	Mean Score	Standard Deviation	Mean Score	Standard Deviation
2016	428	108	452	98	407	111
2021	413	100	422	99	405	100

The chart below illustrates the trend in the average scores of Iranian students over the years of the assessment, both overall and by gender.

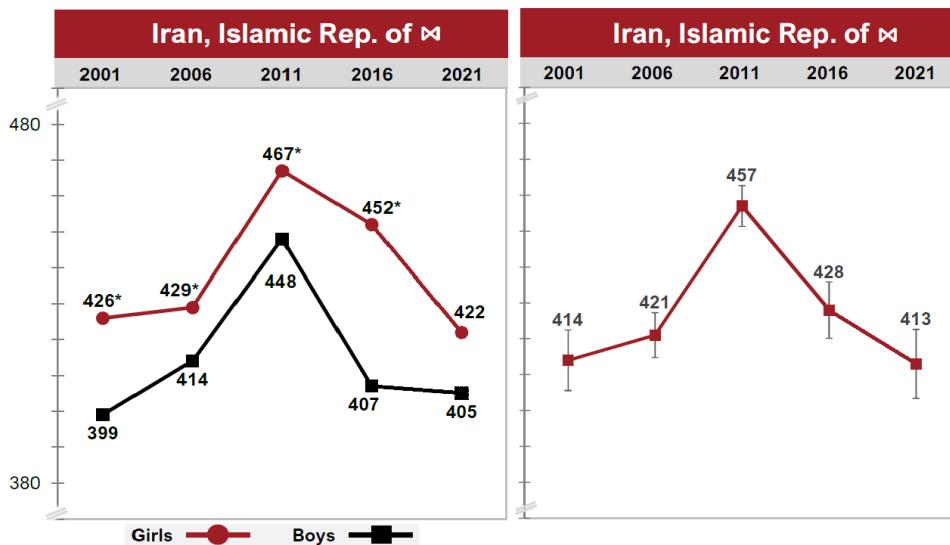


Figure 3 Trend of Average Scores of Iranian Students Overall and by Gender

The chart below illustrates the distribution of Iranian students' scores across the five cycles of the assessment.

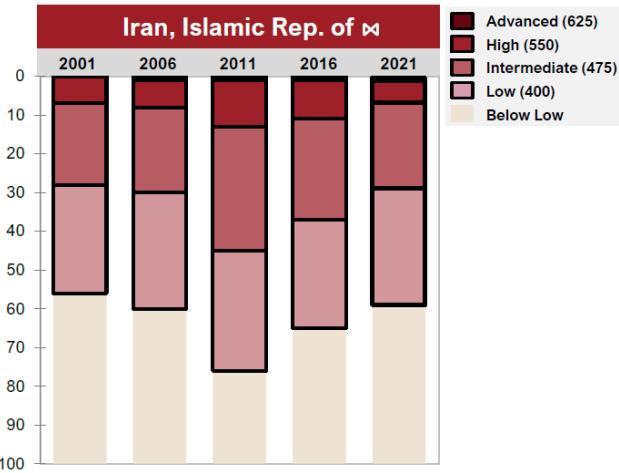


Figure 4 Distribution of Iranian Students' Scores

The chart below displays the probability density plot of Iranian students' scores for the 2016 and 2021 cycles.

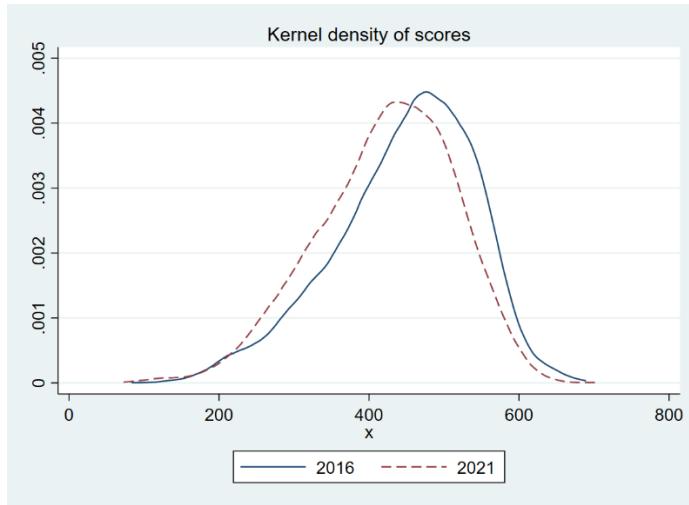


Figure 5 Probability Density Plot of Students' Scores in 2016 and 2021

As previously mentioned, the PIRLS questionnaires provide valuable information regarding students' families and parents, living environments, schools, teachers, and students' attitudes toward education. For instance, parental education is defined as a categorical variable with nine levels, which, in this study, were consolidated into four categories: the first category includes parents with no literacy skills, the second covers primary education, the third encompasses middle and high school education, and the fourth includes university education. Another example is the school principal's

questionnaire, which asks about the type of residential area in which the school is located, considering population density and whether the area is urban or rural.

The conditional probability density functions of students' scores in the 2016 and 2021 assessments, relative to four factors—gender, attendance in preschool, mother's education level, and students' residential location—are presented in the charts below.

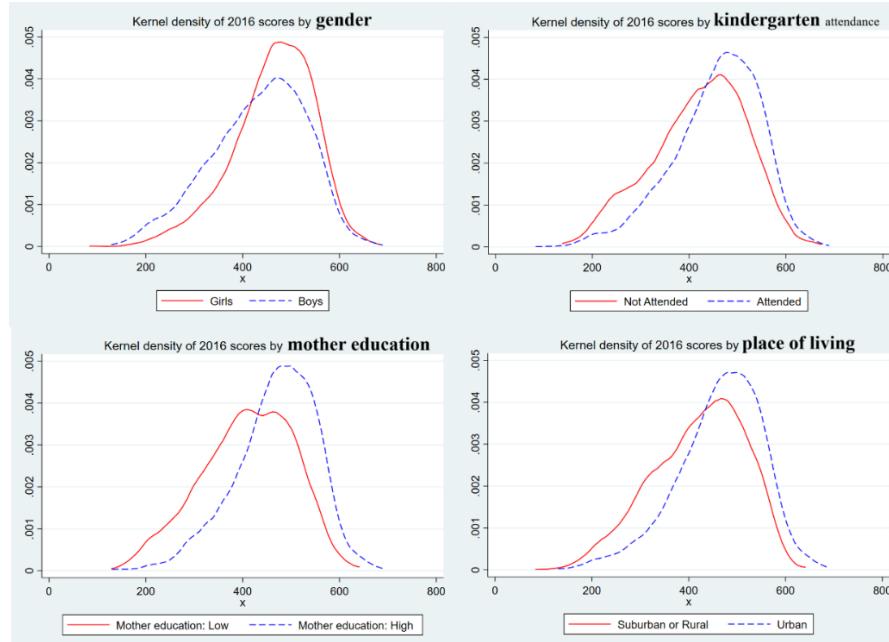


Figure 6 Conditional Probability Density of Students' Scores in 2016

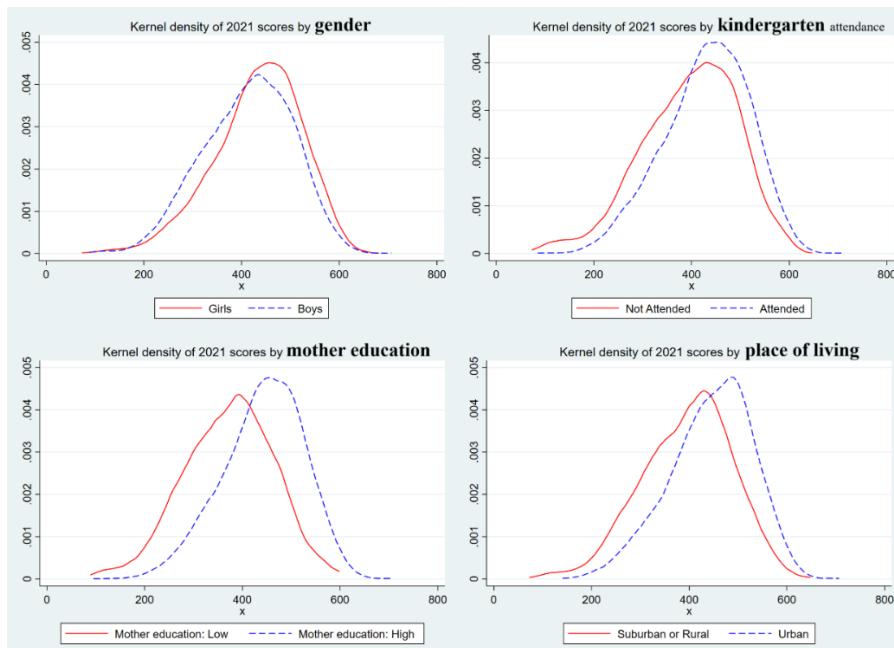


Figure 7 Conditional Probability Density of Students' Scores in 2021

4 Results

Educational Opportunity Inequality Index

As previously mentioned, the purpose of this study is to calculate an index for measuring educational opportunity inequality in Iran. This index estimates the lower bound of educational opportunity inequality. Initially, the index was calculated separately for the fourth (2016) and fifth (2021) PIRLS cycles. The calculation was conducted using a parametric approach and an ex-ante framework, employing two distinct methods as outlined in the methodology section. The first method, referred to as the decomposition method, involves averaging the set of circumstances and indirectly calculating the inequality index. The second method reports the R-squared value of a linear regression of students' scores on the set of circumstances. The table below presents the results obtained from both methods. As observed, there is strong consistency between the results of the R-squared and decomposition methods.

Table 3 Index of Inequality of Educational Opportunity in Iran for 2016 and 2021

	R ²	Decomposition
2016	0.3752	0.3603
2021	0.3847	0.3625

Based on the results, inequality in educational opportunity in Iran showed an overall increasing trend between 2016 and 2021. However, the increase is not substantial enough to be considered statistically significant.

Decomposition of the Effect of Circumstances

The most significant factors contributing to inequality of educational opportunity are parental education levels and the cultural environment at home. Following these, ethnicity and parental involvement in preschool education also play critical roles. As previously mentioned, the cultural environment at home encompasses variables such as the number of books available at home, access to a computer, a study desk, internet connectivity, and access to a private room. The parental education factor is also determined by the education levels of the student's mother and father. Ethnicity is derived from the question

in the parental questionnaire regarding the frequency of the student speaking the test language at home.

Table 4 The Relative Impact of Various Factors on Educational Opportunity Inequality

	Student Gender	Parental Education	Ethnicity	Student Residence	Cultural Environment of the Home	Kindergarten Attendance	Household Wealth	Teacher Characteristics	School Characteristics	Parental Engagement
2016	3.3	22.6	12.9	10.5	19.6	1.6	7.4	5.1	5.6	11.4
2021	3.3	23	9.9	7	22.3	1.3	6.2	5.5	7.5	14

Given the high importance of the home cultural environment in creating inequality, it is helpful to look at it more closely. The table below shows the relative impact of the factors that make up this index.

Table 5 The relative impact of the circumstances contributing to cultural environment of home

	Number of books at home	Access to study desk	Access to private room	Access to internet	Access to computer
2016	47.5	21	1.8	14	15.7
2021	46.8	16.4	0.1	15.9	20.8

One of the notable findings from the results is the increased influence of the home cultural environment and the decreased impact of ethnicity and location on inequality of educational opportunity. A closer look, based on the Shapley decomposition results, reveals that the rise in the importance of the home cultural environment is primarily due to increased significance of internet and computer access. As we know, the COVID-19 pandemic led to the transition of schools to online learning in Iran, making access to the internet and computers crucial for virtual education. This explains the growing impact of these factors on the achievement gap among students. Conversely, the reduced influence of location (school placement) is also understandable, as virtual education, through centralized online learning platforms, offered more equalized educational quality to students across the country, regardless of their location, thereby diminishing the importance of school type and location.

5 Conclusion and Discussion

As shown in the results, inequality in educational opportunity in Iran slightly increased between 2016 and 2021, but the change is not significant. It was expected that switching to remote education during this time might reduce inequalities since in-person learning was no longer a factor. However, this didn't happen. Instead, the decline in the quality of education and the overall "educational poverty" in the country contributed to widening gaps (see Figure 3). The average student scores dropped by about 7% in 2021 compared to 2016. Additionally, the 2021 score distribution reveals a noticeable decline in the number of students achieving high scores.

The main factors contributing to this inequality were identified through Shapley decomposition analysis. These factors include:

1. Parents' Education:

The education level of parents—both father and mother—plays a major role. Parents with higher levels of education are generally more concerned about their children's schooling and tend to provide better resources to support their learning.

2. Home Environment:

This factor includes the number of books at home and access to tools like computers, study desks, and the internet. Among these, the number of books in the home has the strongest impact, reflecting the family's attitude toward learning and reading. Notably, because the 2021 test was conducted after the COVID-19 pandemic, online classes were the norm. This made access to computers and the internet even more critical, increasing their importance in educational inequality.

3. Parental Involvement:

Parental participation in early education—such as reading stories to children—also significantly affects gaps in student performance.

4. Ethnicity and Location:

Ethnicity is reflected in the language spoken at home. Students who do not speak the test language at home often face challenges, as they might not have had enough time to master it by the age of 10. Location refers to whether the school is in an

urban or rural area. Schools in rural or less populated areas typically have fewer resources compared to urban schools, which contributes to inequality.

To address these inequalities, policymakers should focus on these key factors. For example, since school location plays a significant role, additional funding could be allocated to underprivileged areas to improve educational resources and offer extracurricular programs.

To reduce inequality caused by limited access to computers and the internet, efforts could focus on expanding internet coverage across the country so that all students can benefit, regardless of where they live. Finally, to encourage parental involvement in early education, distributing educational materials and children's books nationwide, along with raising awareness about the importance of parental engagement, can help bridge the gap.

References

- Alesina, A., & La Ferrara, E. (2005). Preferences for redistribution in the land of opportunities. *Journal of public Economics*, 89(5-6), 897-931 .
- Arneson, R. J. (1996). Equality and equal opportunity for welfare. *INTERNATIONAL LIBRARY OF CRITICAL WRITINGS IN ECONOMICS*, 63, 416-432 .
- Bedard, K., & Ferrall, C. (2003). Wage and test score dispersion: some international evidence. *Economics of education review*, 22(1), 31-43 .
- Blau, F. D., & Kahn, L. M. (2005). Do cognitive test scores explain higher US wage inequality? *Review of Economics and statistics*, 87(1), 184-193 .
- Bourguignon, F., Ferreira, F. H., & Menéndez, M. (2007). Inequality of opportunity in Brazil. *Review of income and Wealth*, 53(4), 585-618 .
- Bourguignon, F., Ferreira, F. H., & Walton, M. (2007). Equity, efficiency and inequality traps: A research agenda. *The Journal of Economic Inequality*, 5, 235-256.
- Carter, M. (2006). World Bank. World Development Report 2006: Equity and Development. *JOURNAL OF ECONOMIC LITERATURE*, 44(4), 1075 .
- Castelló ,A., & Doménech, R. (2002). Human capital inequality and economic growth: some new evidence. *The economic journal*, 112(478), C187-C200 .
- Checchi, D., & Peragine, V. (2005). Regional disparities and inequality of opportunity: the case of Italy .
- Checchi, D & ,Peragine, V. (2010). Inequality of opportunity in Italy. *The Journal of Economic Inequality*, 8, 429-450 .
- Dardanoni, V., Fields, G. S., Roemer, J. E., & Sánchez Puerta, M. L. (2006). How demanding should equality of opportunity be, and how much have we achieved ?
- Dworkin, R. (1981a). What is equality? Part 1: Equality of welfare. *Philosophy and Public Affairs*, 10(3).185-246.
- Dworkin, R. (1981b). What Is Equality? Part 2: Equality of Resources. *Philosophy and Public Affairs*, 10(4), 283-345.
- Ferreira, F. H., & Gignoux, J. (2011). The measurement of inequality of opportunity: Theory and an application to Latin America. *Review of income and Wealth*, 57(4), 622-657 .
- Ferreira, F. H., Gignoux, J., & Aran, M. (2011). Measuring inequality of opportunity with imperfect data: the case of Turkey. *The Journal of Economic Inequality*, 9, 651-680 .
- Ferreira, F. H., & Gignoux, J. (2014). The measurement of educational inequality: Achievement and opportunity. *The World Bank Economic Review*, 28(2), 210-246 .
- Gamboa, L. F., & Waltenberg, F. D. (2012). Inequality of opportunity for educational achievement in Latin America: Evidence from PISA 2006–2009. *Economics of education review*, 31(5), 694-708 .
- Hashemi, A., & Intini, V. (2015). Inequality of opportunity in education in the Arab region. Available at SSRN 2797695 .
- Lasso De La Vega, C., Lekuona, A., & Orbe, S. (2020). Reexamining the inequality of opportunity in education in some European countries. *Applied Economics Letters*, 27(7), 544-548 .
- Lefranc, A., Pistolesi, N., & Trannoy, A. (2008). Inequality of opportunities vs. inequality of outcomes: Are Western societies all alike? *Review of income and Wealth*, 54(4), 513-546 .
- Marconi, G. (2018). Education as a long-term investment: The decisive role of age in the education-growth relationship. *Kyklos*, 71(1), 132-161 .
- Marrero, G. A., & Rodríguez, J. G. (2009). Inequality of opportunity and growth. Preliminary draft. ECINEQ meeting. Buenos Aires,
- Marrero, G. A., Palomino, J. C., & Sicilia, G. (2024). Inequality of opportunity in educational achievement in Western Europe: contributors and channels. *The Journal of Economic Inequality*, 22(2), 38 .¹⁰⁻³

- Morrisson, C., & Murtin, F. (2007). Education inequalities and the Kuznets curves: a global perspective since 1870 .
- Peragine, V., Lagravinese, R., Palmisano, F., & Intini, V. (2015). Inequality of opportunity for educational achievement in Arab Region: Evidence from PISA 2006–2009–2012. *UN-ESCWA Working Paper* .
- Rawls, J. (1971). *A theory of justice*. Rawls. The Belknap .
- Roemer, J. (1998). Equality of opportunity, Harvard U. Press, Cambridge .
- Salehi-Isfahani, D., Hassine, N. B., & Assaad, R. (2014). Equality of opportunity in educational achievement in the Middle East and North Africa. *The Journal of Economic Inequality*, 12, 489-515 .
- Sen, A. (1979). Equality of what? The Tanner lecture on human values. *Stanford University, May, 22, 1979* .
- Shapley, L. S. (1953). A value for n-person games. Contributions to the Theory of Games, 2.
- Shorrocks, A. F. (1984). Inequality decomposition by population subgroups. *Econometrica: Journal of the Econometric Society*, 1369 .¹¹⁸⁰
- Thomas, V., Wang, Y., & Fan, X. (2001). *Measuring education inequality: Gini coefficients of education* (Vol. 2525). World Bank Publications .
- Van De Gaer, D. (1995). Equality of opportunity and investment in human capital .