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GINI INDEX OF EDUCATION BY AGE GROUP

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A New Data Set of Educational Inequality in the World, 1950–2010

Gini Index of Education by Age Group ☆

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Abstract - The research on educational inequality plays an essential role in characterizing the fairness and effectiveness of educational systems, and monitoring and evaluating processes of educational development. This paper introduces a new quinquennial data set of educational inequality of 146 countries, from 1950 to 2010, and it is the first to present a Gini index of education by 5-year age intervals and by sex for a broad panel. We use the Gini index of education as a measure of the distribution of years of schooling, with a more in-depth approach, compared to existing data sets (Castelló and Doménech, 2002; Thomas et al., 2001, 2003; Checchi, 2004; Araujo et al., 2004; Lim and Tang, 2008; Földvári and Van Leeuwen, 2010; Morrisson and Murtin, 2010; Meschi and Scervini, 2010; Castelló, 2010a). We use data on educational attainment of Barro and Lee (2010) taking into consideration, for the first time, the over time changes on the duration of schooling cycles, in each country and for each age group. This approach can significantly improve the measurement of inequality in education by producing estimates of the Gini Index of Education more realistic and reliable especially when it comes to international comparisons. We made a decomposition of the overall educational inequality to measure the contribution of each component. The results show that (i) even though educational inequality has been declining for most countries during the last six decades, it is not occurring in a uniform manner because it depends on age group, gender and development level for each country or region. (ii) The data indicate the existence of the Education Kuznets Curve when we consider the standard deviation of schooling. (iii) It also suggests that the average years of schooling and the Gini index of education are negatively related.

JEL Classification: D63, I21, J24, O15
Keywords: Educational inequality, Gini index of Education, Educational attainment, Age Group, Duration of schooling cycles

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☆ The data set of educational inequality measured by the Gini index of education of 146 countries from 1950 to 2010 is availbale in www.education-inequality.com

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I. Introduction

The analysis of inequality has been the centre of interest for scholars in the social science. However, most empirical work on inequality use a uni-dimensional monetary perspective which may not be sufficient for adequately characterizing this multidimensional phenomenon. The World Bank's World Development Report 2006 titled "Equity and Development" moved for the first time beyond the question of income distribution, to emphasizing on inequalities in opportunity key dimensions, such as health and education. While many questions about healthcare inequities have raised a lot of concern to planners and policy makers, little attention was paid to educational inequality. During the last decades, however, researchers have realized the importance of putting more emphasis on educational inequalities. A recent but fast growing literature concerning education inequality has emerged. In fact, several data sets have been created to measure educational inequality (Castelló and Doménech, 2002; Thomas et al., 2001, 2003; Checchi, 2004; Araujo et al., 2004; Lim and Tang, 2008; Földvári and Van Leeuwen, 2010; Morrisson and Murtin, 2010; Meschi and Scervini, 2010; Castelló, 2010a). The most popular and largely used is the one proposed by Thomas et al. (2001) who calculated a Gini index of education of the population aged 15 and over, based on school attainment data[1]. Nevertheless, few studies have explored educational inequalities by age group. This paper introduces a new quinquennial data set of educational inequality for 146 countries, from 1950 to 2010, which is the first to present a Gini index of education by 5-year intervals and by sex for a broad panel. The Gini index of education is used as a measure of the distribution of years of schooling, with a more in-depth approach, compared to existing data sets.

II. Literature Review

The research on educational inequality plays an essential role in characterizing the fairness and effectiveness of educational systems, and monitoring and evaluating processes of educational development. There is a large and rapidly expanding body of work analyzing the distribution of education itself and its relation to the expansion of education, income inequality, economic growth, or with other aspects (health (Galea et al., 2007; Lê et al., 2010), corruption (Patrawart, 2010), social cohesion (Green et al., 2006; Green, 2011), migration (McKenzie and Rapoport, 2007), democracy (Castelló, 2008), macroeconomic volatility (Checchi and García-Peñalosa, 2004), fertility (Hori, 2011) …).

The Gini Index of Education is a measure of the relative inequality of schooling distribution. It can be calculated using educational resources data, achievement, enrollment, or attainment data. UNESCO's Institute for Statistics (Sherman and Poirier, 2007) analyzed financial and human resources using the

[1] Educational attainment is the most frequently used human capital proxy in the empirical literature. Indeed, average years of schooling gained popularity as adult literacy rates grasp only the first stages of human capital accumulation and ignore knowledge and skills acquired beyond basic levels. Enrolment ratios ignore the cumulative benefits of completing additional years of schooling.

Gini index of spendings per pupil and pupil-teacher ratios for 16 of the world's largest countries. Rao and Jani (2011) estimated the Gini index of pupil-teacher ratios for the case of Indonesia from 1986 to 2008. Soares (2006) calculated a Gini index of education based on cognitive achievement data for the case of Brazil. Collins (2009) estimated the Gini index of enrollment for all 24 provinces and municipalities of Cambodia.

The distribution of human capital is one possible reason for the lack of improvement in development prospects of some countries. Some empirical studies analyzed the relationship between educational inequality and economic growth using cross-countries data (Birdsall and Londoño, 1997; Castelló and Doménech, 2002; Bowman, 2007); time series data (Rao and Jani, 2008; Changzheng and Jin, 2010); panel data (Lopez et al., 1998; Park, 2006; Klasen and Lamanna, 2009; Baliamoune-Lutz and McGillivray, 2009; Castelló, 2010b; Ilon, 2011) or intra-country data (Yang and Li, 2007; Hassan and Mirza, 2007; Digdowiseiso, 2009; Simões and Duarte, 2010; Rodríguez-Pose and Tselios 2010; Güngör 2010).

Concerning the relationship between education inequality and income distribution, many studies have included educational inequality as independent variables in explaining the change of income inequality (Chiswick, 1974; Marin and Psacharopoulos, 1976; Psacharopoulos, 1977; Winegarden, 1979; Ram, 1984, 1995; Caniglia, 1988; Lam and Levison, 1992; Park, 1996; Chu, 2000; De Gregorio and Lee, 2002; Checchi, 2004; Lin, 2007; Yang et al., 2009; Rodríguez-Pose and Tselios 2009; Földvári and Van Leeuwen 2010). Some of them have used cross-country data, while others have utilized intra-country data. Most of them have found similar evidence; that the educational inequality has a positive effect on income inequality.

Concerning the relationship between education and its distribution, some studies have confirmed the existence of the so-called Education Kuznets Curve[2], while others affirmed a negative correlation. Maas and Criel (1982) found that the enrollment Gini coefficients were negatively related to the average enrollment rate in East African countries. Thomas et al. (2001, 2003), Checchi (2004), Castelló and Doménech (2002) found a negative correlation between the Gini index of educational attainment and the average years of schooling. On the other hand, using the standard deviation of education, Ram (1990), Londoño (1990), Sinnathambu (2002), Thomas et al. (2001, 2003), De Gregorio and Lee (2002), Lorel (2008) and Lim and Tang (2008) found an education Kuznets curve, while Lin (2007), Hojo (2009) and Morrison and Murtin (2010) reveal the existence of the inverted U-shaped relationship using the Gini coefficient of educational attainment.

We present in Table n°1 an overview of existing data sets of Inequality in Educational Attainments. Using education attainment data of Barro and Lee (1997), Lopez et al. (1998) were among the first to calculate a Gini index of educational attainment[3]. They presented a data set of 12 countries from 1970 to

[2] See V.2

[3] Using data from U.S. census: 1960, Verway (1966) calculated a Gini index of educational attainment for the population aged over twenty-five allover 51 states for the United States and for

1990 and another one of 20 countries in a later version (May 1999). Thomas et al. (2001) also constructed a data set of Gini coefficient of education for 85 countries from 1960 to 1990, and expanded their data set to 140 Countries from 1960 to 2000 in an updated version (Thomas et al., 2003) using attainment levels from Barro and Lee (2001). Starting from education attainment data of Barro and Lee (1997), Castelló and Doménech (2002) also constructed a data set of Gini index of education which includes 108 countries from 1960 to 2000, with a total of 935 observations.

Checchi (2004) proposed a quinquennial data set to analyze the relationship between income and education inequalities. He calculated a Gini index on educational attainment of 848 observations corresponding to 117 countries between 1960 and 1995. Araujo et al. (2004) also constructed a data set of educational inequality from individual record data in household surveys for 124 countries. Lim and Tang (2008) constructed a data set of Gini index of education which includes 99 countries for nine five-year periods starting from 1960 to 2000 for the population aged 25 and over.

Földvári and Van Leeuwen (2010) dealt with the issue of whether inequality in education should be closely related to income inequality. They calculated two educational Gini-coefficients for the population aged 15 years and over from two different data of educational attainment, one with Barro and Lee (2001) data set and the other with Cohen and Soto (2007) data set. Morrison and Murtin (2010) built a data set on national distributions of education for 78 countries since 1870. They used the Gini index of education and other indices[4] and exhibited an inverted-U shape curve of human capital inequality within countries. Meschi and Scervini (2010) created also a data set which provides cross-country measures of educational inequality, using four international surveys[5]. The data set contains 13 cohorts, aggregated at 5-years intervals for a sample of 31 countries. Following the procedure of Castelló and Doménech (2002), Castelló (2010a) updated the Gini index of education using the latest version of Barro and Lee (2010).

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the District of Columbia. He utilized nine levels of schooling in the estimation of the Gini index of education.

[4] The Theil index of education and the coefficient of variation of schooling.

[5] The European Social Survey, the European Union Statistics on Income and Living Conditions, the International Adult Literacy Survey and the International Social Survey Programme.

Table n°1: Overview of data sets on Inequality in Educational Attainments

Authors	*Number of countries*	*Data sources*	*Number of levels of education*	*Period*	*Population*
Lopez et al. (1998)	12	BL (1996)	7	1970-1995	15+
Lopez et al. (1999)	20	BL (1996)	7	1970-1995	15+
Thomas et al. (2001)	85	BL (1996)	7	1960-1990	15+
Zhang and Li (2002)	107	BL (1996)	-	1960-1990	25+
Castelló and Doménech (2002)	108	BL (2001)	4	1960-2000	15+
Thomas et al. (2003)	140	BL (2001)	7	1960-2000	15+
Checchi (2004)	117	BL (1997)	4	1960-1995	25+
Araujo et al. (2004)	124	Household surveys	-	~ 2000	ACE
Lim and Tang (2008)	99	BL (2001)	7	1960-2000	25+
Földvári and Van Leeuwen (2010)	92 / 109	CS (2007) / BL (2001)	4	1960-2000	15+
Morrisson and Murtin (2010)	78	MM (2009)	7	1870-2010	15-64 / 15+
Meschi and Scervini (2010)	31	ESS/ EU-SILC/ IALS / ISSP	-	-	13 cohorts
Castelló (2010a)	83	BL (2010)	4	1960-2000	25+

ACE: Adults who have completed their education, 15+: Population aged 15 and over, 25+: Population aged 25 and over, ~2000: 2000 or the closest year, BL: Barro and Lee, CS: Cohen and Soto, MM: Morrison and Murtin. ESS: European Social Survey, EU-SILC: European Union Statistics on Income and Living Conditions, IALS: International Adult Literacy Survey, ISSP: International Social Survey Programme.

Source: The authors

III. Data

Several data sets on educational attainment have been produced to quantify the human capital stock. These data sets, utilized in the literature on growth models, have been used to estimate a quantitative index of education inequality. The following is a review all of these data sets in chronological order (Table n° 2).

Table n°2: Educational Attainments Data Sets

Authors	***Number of countries***	***Period***
Psacharopoulos and Arriagada (1986)	99	1960-1980
Kyriacou (1991)	121	1965-1985
Lau et al. (1991)	58	1960-1986
Barro and Lee (1993)	129	1960-1985
Nehru et al. (1995)	85	1960-1987
Ahuja and Filmer (1996)	71	1985-1995
Barro and Lee (1996)	126	1960-1990
De la Fuente and Domenech (2000)	21 {OECD}	1960-1990
Barro and Lee (2001)	142	1960-2000
De la Fuente and Domenech (2006)	21 {OECD}	1960-1990
Cohen and Soto (2007)	95	1960-2000
Lutz et al. (2007)	120	1970-2000
Morrisson and Murtin (2009)	74	1870-1960
Filmer (2010)	98	1989-2008
Barro and Lee (2010)	146	1950-2010

Source: Authors

Psacharopoulos and Arriagada (1986) presented one of the first attempts to measure average years of schooling using information on the educational composition of the labor force from national census publications for six levels of educational attainment[6]. They provided data sets for the population aged 25 and older for 99 countries from 1960 to 1980. Also, Kyriacou (1991) developed a data set to estimate years of schooling in the labor force for 121 countries from 1970 to 1985, by regressing data on educational attainment from Psacharopoulos and Arriagada (1986) to gross school enrolment ratio published in UNESCO's Statistical Yearbook.

In a previous study for the World Development Report 1991, Lau et al. (1991) used perpetual inventory method to construct panel data of average years of schooling for 58 developing countries from 1960 to 1986 for the population aged from 15 to 64. Psacharopoulos and Arriagada (1992) updated their data set by adding new information on the educational composition of the labour force for 34 countries. After one year, Barro and Lee (1993) presented a data set on educational attainment disaggregated by sex for the adult population aged 25 and over from 1960 to 1985. Barro and Lee (1996) updated their previous data set

[6] No schooling, incomplete primary, complete primary, incomplete secondary, complete secondary, and higher.

(1993) by expanding the number of countries to 126 and the period which covered from 1960 to 1990, and providing new estimates of educational attainment for the population aged 15 and over. Nehru et al. (1995) used the perpetual inventory method adjusted for repetition, dropouts, and mortality in order to develop a data set of average years of schooling of the population aged between 15 and 64 for 85 countries from 1960 to 1987. De la Fuente and Domenech (2000) modified Barro and Lee's (1996) data set for 21 high-income OECD countries from 1960 to 1990 for the population aged 25 and older.

Barro and Lee (2001) improved their earlier estimates by using gross enrollment rates adjusted for repeaters and taking into account changes of duration of schooling cycles for 142 countries, of which 109 have completed information at five-year intervals from 1960 to 2000. De la Fuente and Domenech (2006) revised and partially extended their previous data set (De la Fuente and Domenech, 2000) by incorporating unpublished information supplied by the OECD and by the national statistical offices of approximately a dozen member states. Then, Cohen and Soto (2007) constructed a data set of 95 countries at ten-year intervals from 1960 to 2010. They provided estimates of attainment for the population aged 15 and over, the population aged 25 and over and the population aged 15 to 64. Similarly, The World Population Program of the International Institute for Applied Systems Analysis (IIASA) and the Vienna Institute for Demography (VID) (2007), developed a data set of educational attainment for 120 countries from 1970 to 2000. The dataset jointly produced by IIASA and VID gives the full educational attainment distributions at four levels of education[7] and presents the average years of schooling by five-year age groups and for the population aged 15 and over, and 25 and over. Morrisson and Murtin (2009) managed to fill the gap in the attainment data for early periods of time. They actually applied the perpetual inventory method to construct their data set from 1870 to 1960, for 74 countries.

Barro and Lee (2010) made the most recent data set which includes 146 countries from 1950 to 2010. The data is provided by sex and 5-year age intervals. They have improved the accuracy of estimation by using consistent census data, disaggregated by age group, along with new estimates of mortality rates and completion rates by age and education level.

Since Cohen and Soto (2007) and Barro and Lee (2010) are the most commonly used and most accurate data sets , Table n° 3 is used to present a comparison considering different criteria between both data sets. In fact, data sources on educational attainments of Cohen and Soto (2007) are OECD database and censuses published by UNESCO8. Barro and Lee (2001, 2010) argued that there is a significant difference between the OECD data and UNESCO censuses which can cause inconsistency over time in case of a mix between the two sources. Indeed, OECD data comes mostly from households' surveys which are based on samples of labor force and are obviously less robust than censuses. In addition, OECD data are available only for the 1990s, which can lead to underutilization of available information.

[7] No education, primary, secondary and tertiary education

[8] In addition to OECD and UNESCO data sources, Cohen and Soto (2007) also used data on educational attainment from Singapore and Bangladesh's statistical offices websites.

Table n°3: Comparison of Cohen and Soto's (2007) and Barro and Lee's (2010) data sets

Criteria	*Cohen and Soto (2007)*	*Barro and Lee (2010)*
Data sources on educational attainment	OECD / UNESCO data	UNESCO data
Number of advanced countries (AC)	22	24
Number of UNESCO censuses for the AC	8	119
Number of total data sources for the AC	48	119
Number of developing countries (DC)	73	122
Number of UNESCO censuses for the DC	51	392
Number total data sources for the DC	70	392
Mortality rates	By age groups	By age groups and by educational levels
Duration of schooling cycles	Homogenous	By age groups and over time
Reliability ratio* of series in 10-year differences	0.88	1.00
Reliability ratio of series in levels	0.90	0.99

Source: The authors

*As used by Krueger and Lindahl (2001) in checking quality of schooling data, the reliability ratio gauges the fraction of the variability of a (unobserved) true variable in the total variability of the variable measured with error.

Barro and Lee (2010) used only UNESCO censuses, with substantially more sources than Cohen and Soto (2007). Indeed, Cohen and Soto's estimation used only 51 UNESCO censuses among 70 data sources for 73 developing countries and 8 UNESCO censuses among 48 data sources for 22 advanced countries, compared to 392 UNESCO censuses for 122 developing countries and 119 for 24 advanced countries in Barro and Lee's (2010) sample. In fact, Cohen and Soto (2007) considered the variation in mortality rates by age groups not by educational levels. They have used homogenous duration of schooling cycles rather than variations by age groups and over time utilized by Barro and Lee's (2010) estimation. As Barro and Lee (2010) demonstrated, the reliability ratio for their estimation is greater than the one of Cohen Soto (2007), in levels and in 10-year differences, in years of schooling for the population aged 15 years and older. Specifically, while the new Barro-Lee data set has reliability ratios of 0.99 for levels and 1.00 for differences, the reliability ratios of Cohen-Soto (2007) are 0.90 for levels and 0.88 for differences.

As mentioned earlier, several studies have provided cross-country measures of educational inequality over time. Also, a time series analysis of the educational inequality dynamics has been carried out for many countries[9] (Taiwan, Brazil, Indonesia, Estonia…). In addition, a particular attention has been given to regional and provincial analysis of educational inequality such as (Mesa, 2007; Appiah-Kubi, 2008; Lorel, 2008; Qian and Smyth, 2008; Holsinger, 2009; Tomul, 2009; Hojo, 2009; Burt and Park, 2009; Fidalgo et al., 2010; Benaabdelaali and Kamal, 2010) who have analyzed respectively the cases of The Philippines, Ghana, Brazil, China, Vietnam, Turkey, Japan, Korea, Portugal, and Morocco.

However, few datasets have explored the educational inequalities by age group[10]. The data set suggested in this paper gives further insight on educational inequality compared to the existing data sets for many reasons:

First, as the quality of the estimation of educational attainment levels contributes to the accuracy of the estimation of the Gini index, we use Barro and Lee's (2010) data set, whose estimation is more accurate and which has specific advantages, as discussed earlier, compared to other data sets.

Second, the data set is constructed with seven levels of education[11]. All data sets constructed using only four levels of education present a real limitation. Indeed, the Checchi (2004), Castelló and Doménech (2002), Földvári and Van Leeuwen (2010), and Castelló's (2010a) studies have used only four levels of education in their Gini coefficient calculations. Subsequently, these works do not include the variation within a cycle because they do not differentiate between those who actually completed a level of education and those who did not.

[9] See for example (Lin, 2007; Lorel, 2008; Lin and Yang, 2009; Digdowiseiso, 2010)

[10] The Socio-Economic Database for Latin America and the Caribbean {CEDLAS and The World Bank: SEDLAC (2011)} presents information on Gini coefficient for the distribution of years of education by age group for most countries in Latin America and the Caribbean.

[11] No formal education, incomplete primary, complete primary, lower secondary, upper secondary, incomplete tertiary and complete tertiary.

Third, we take into account the variation of the duration of schooling cycles. Indeed, all previous data sets on Gini index of education included neither the variation of duration of schooling cycles over time, nor the heterogeneity of age group's duration system: in a given country, different generation groups have different schooling cycles duration for each education level (cycle). In fact, we take into account the heterogeneity of age group duration system over time[12]. Our duration of schooling cycles data used in the calculation of the Gini index makes neither a restriction nor stress on our data set of inequality in educational attainment, on the contrary of the duration of schooling cycles by Thomas et al (2001, 2003) and Lim and Tang (2008). Thomas et al (2001, 2003) have used Psacharopoulos and Arriagada's (1986) data of cycles duration which are fixed in time and present only the duration of a broad secondary phase rather than the lower and upper secondary phases. In fact, the authors have used an approach which does not seem to be compatible with the data they used. Indeed, they hypothesized that the duration of schooling in the lower secondary cycle corresponds to the half of the duration of a broad secondary phase. Furthermore, Lim and Tang's (2008) schooling duration cycles are drawn from the UNESCO Institute for Statistics Database which restricts their data set to only 99 countries.

Finally, it's the first data set to provide an education Gini index by 5-year age intervals and by sex for a broad 146 countries and also for aggregated groups of countries or age intervals, considering the variation and the heterogeneity within these aggregated groups.

These adjustments helped to make better estimation of the Gini Index of Education. Our approach can significantly improve the measurement of inequality in education by producing more realistic and reliable estimates of the Gini Index of Education especially when it comes to international comparisons.

IV. Methodology: Estimation of the Gini index of education.

Our data set is about inequality in educational attainments measured by the Gini index of educational attainments. We adapted the formula of Thomas et al., 2001 to calculate a quinquennial Gini index of education of 146 countries by 5-year intervals and by sex and constructed a structural formula of Gini index of education of aggregated groups which employs all the abundance of disaggregated data (for a broad age group {15+, 25+, [15, 65], [15, 24],[25, 34]…} and for groups of countries {The world, Advanced Countries, Developing Countries[13], Middle East and North Africa, Sub-Saharan Africa, Latin America and the Caribbean, East Asia and the Pacific , South Asia, and Europe and Central Asia}).

[12] Data on duration of schooling cycles can be obtained from the authors upon request.

[13] The developing group is further broken down into six regions: Middle East/North Africa (18 countries), Sub-Saharan Africa (33), Latin America/Caribbean (25), East Asia/Pacific (19), South Asia (7), and Europe and Central Asia (20).

IV.1.Gini index of education by age group

$$Gini_{c,t}^{a} = \frac{\sum_{i=2}^{n}\sum_{j=1}^{n} p_{c,i,t}^{a}\left|y_{c,i,t}^{a} - y_{c,j,t}^{a}\right| p_{c,j,t}^{a}}{2 * \sum_{j=1}^{n} p_{c,j,t}^{a} y_{c,j,t}^{a}}$$

Where:

- $Gini_{c,t}^{a}$: the Gini index of education of age group "a" of the country "c" at the time "t".
- Age group "*a*" corresponds to a =1 to 15–19 age group, a =2 to 20–24 age group, a = A =13 to 75 and above, a=15+ to the population aged 15 and above and finally a=25+ to the population aged 25 and above.
- *n* corresponds to the number of levels of education which is equal in our study to 7 levels.
- *i* and *j* are educational levels. j =1 for no formal education, j=2 for incomplete primary, j =3 for complete primary, j =4 for incomplete secondary, j =5 for complete secondary, j =6 for incomplete tertiary, j =7 for complete tertiary.
- $p_{c,j,t}^{a}$: The fraction of group "a" in the country "c" having attained the educational level "j" at time "t".
- $y_{c,j,t}^{a}$: The number of years of schooling accumulated by group "a" in the country "c" to attained the educational level "j" at time "t"[14].

IV.2. Gini index of education of aggregated group using disaggregated data by age

Instead of calculating the weighted average Gini index for world region or country group, we construct a structural formula which allow us to better harness the wealth of disaggregated data in order to calculate a Gini index of education of aggregated group (group of age interval or group of countries = region) taking into consideration changes over time of schooling cycles duration in each country and for each age group.

a) Gini index of a broad age group[15]

$$Gini_{c,t}^{G} = \frac{\sum_{a\in G}\sum_{a'\in G}\sum_{i=1}^{n}\sum_{j=1}^{n} p_{c,i,t}^{a} L_{c,t}^{a}\left|y_{c,i,t}^{a} - y_{c,j,t}^{a'}\right| p_{c,j,t}^{a'} L_{c,t}^{a'}}{2\times\left[\sum_{a\in G}\sum_{j=1}^{n} p_{c,j,t}^{a} L_{c,t}^{a} y_{c,j,t}^{a}\right]\left[\sum_{a\in G} L_{c,t}^{a}\right]}$$

[14] $y_{c,j,t}^{a}$ is not explicitly available in Barro and Lee's (2010) data set. We calculated $y_{j,t}^{a}$ by merging the two Barro and Lee's (2010) data sets corresponding to the total population and female {MF & F}(see IV.3).

[15] 15+, 25+, [15, 65], [15, 24],[25, 34]…

Where:

- $Gini_{c,t}^{G}$: the Gini index of education of the broad age group "G"[16] for the country "c" at the time "t".
- Age group a (a') corresponds to a =1 (a'=1) to 15–19 age group, a =2 (a'=2) to 20–24 age group; a = A =13 (a' = A =13) to 75 and above, a=15+ to the population aged 15 and above and finally a=25+ to the population aged 25 and above.
- $L_{c,t}^{g} = Pop_{c,t}^{g}$ represents the size of the population at the time "t" , in the age group "g" and for the country "c".

b) Gini index of a broad group of countries[17]

$$Gini_{R,t}^{a} = \frac{\sum_{c\in R}\sum_{c'\in R}\sum_{i=1}^{n}\sum_{j=1}^{n} p_{c,i,t}^{a} L_{c,t}^{a} \left| y_{c,i,t}^{a} - y_{c',j,t}^{a} \right| p_{c',j,t}^{a} L_{c',t}^{a}}{2\times\left[\sum_{c\in R}\sum_{j=1}^{n} p_{c,j,t}^{a} L_{c,t}^{a} y_{c,j,t}^{a}\right]\left[\sum_{c\in R} L_{c,t}^{a}\right]}$$

- $Gini_{R,t}^{a}$: the Gini index of education of age group "a" of the region "R" at the time "t".
- c (c') represents a country in the region "R".

c) Gini index of a broad group of countries (or region "R") and a broad age group

$$Gini_{R,t}^{G} = \frac{\sum_{c\in R}\sum_{c'\in R}\sum_{a\in G}\sum_{a'\in G}\sum_{i=1}^{n}\sum_{j=1}^{n} p_{c,i,t}^{a} L_{c,t}^{a} \left| y_{c,i,t}^{a} - y_{c',j,t}^{a'} \right| p_{c',j,t}^{a'} L_{c',t}^{a'}}{2\times\left[\sum_{c\in R}\sum_{a\in G}\sum_{j=1}^{n} p_{e,j,t}^{g} L_{e,t}^{g} y_{e,j,t}^{g}\right]\left[\sum_{c\in R}\sum_{a\in G} L_{c,t}^{a}\right]}$$

IV.3. Calculation of durations of schooling for each level of education $y_{c,j,t}^{a}$

The corresponding durations of schooling for each level $y_{c,j,t}^{a}$ are not explicitly available in Barro and Lee's (2010) data set. The approach followed to find $y_{c,j,t}^{a}$ is particularly to merge the two Barro and Lee's (2010) data sets of total and female population and to use average years of schooling of each cycle for both total and female population.

The average years of schooling of the primary phase can be defined as the weighted average number of years of education received by individuals who completed and those who have not completed the primary cycle of schooling.

[16] For example G can be the population aged between [25-65], [15-24], or the 15 and over, 25 and over…

[17] The world, Advanced Countries, Developing Countries, Middle East and North Africa, Sub-Saharan Africa, Latin America and the Caribbean, East Asia and the Pacific , South Asia, and Europe and Central Asia..

$$aysp^{a}_{c,t} = \underbrace{p^{a}_{c,2,t}\left[y^{a}_{c,2,t} - y^{a}_{c,1,t}\right]}_{Incomplete\ primary\ cycle} + \underbrace{\left(\sum_{j=3}^{7} p^{a}_{c,j,t}\right)\left[y^{a}_{c,3,t} - y^{a}_{c,1,t}\right]}_{Complete\ primary\ cycle} \quad (1)$$

The average years of schooling for secondary and higher cycles can be obtained following the same reasoning.

$$ayss^{a}_{c,t} = \underbrace{p^{a}_{c,4,t}\left[y^{a}_{c,4,t} - y^{a}_{c,3,t}\right]}_{Incomplete\ secondary\ cycle} + \underbrace{\left(\sum_{j=5}^{7} p^{a}_{c,j,t}\right)\left[y^{a}_{c,5,t} - y^{a}_{c,3,t}\right]}_{Complete\ secondary\ cycle} \quad (2)$$

$$ayst^{a}_{c,t} = \underbrace{p^{a}_{c,6,t}\left[y^{a}_{c,6,t} - y^{a}_{c,5,t}\right]}_{Incomplete\ tertiary\ cycle} + \underbrace{p^{a}_{c,7,t}\left[y^{a}_{c,7,t} - y^{a}_{c,5,t}\right]}_{Complete\ tertiary\ cycle} \quad (3)$$

We must calculate $y^{a}_{c,j,t}$ for each country "c", for each age group "a" and for each time period "t". This results in finding seven unknowns. In order to perform our calculations, we must build a system of seven equations.

As the $y^{a}_{c,j,t}$ are the same for males and females:

$y_{(mf)}{}^{a}_{c,j,t} = y_{(m)}{}^{a}_{c,j,t} = y_{(f)}{}^{a}_{c,j,t}$

We replicated the three equations for the average years of schooling of three cycles {(1), (2) and (3)} for the total and women population. In addition to this, the number of years of schooling accumulated by illiterate population is equal to zero ($\forall$ a $\in$ [1,13]; $y^{a}_{c,1,t} = 0$).

In total, we obtained for each age group of a given country at a given time a system of equations which corresponds to 24674 systems[18] of equations of seven equations and seven unknowns.

$$\begin{cases} aysp_{(mf)}{}^{a}_{c,t} = p_{(mf)}{}^{a}_{c,2,t}\left[y^{a}_{c,2,t} - y^{a}_{c,1,t}\right] + \left(\sum_{j=3}^{7} p_{(mf)}{}^{a}_{c,j,t}\right)\left[y^{a}_{c,3,t} - y^{a}_{c,1,t}\right] \\ aysp_{(f)}{}^{a}_{c,t} = p_{(f)}{}^{a}_{c,2,t}\left[y^{a}_{c,2,t} - y^{a}_{c,1,t}\right] + \left(\sum_{j=3}^{7} p_{(f)}{}^{a}_{c,j,t}\right)\left[y^{a}_{c,3,t} - y^{a}_{c,1,t}\right] \\ ayss_{(mf)}{}^{a}_{c,t} = p_{(mf)}{}^{a}_{c,4,t}\left[y^{a}_{c,4,t} - y^{a}_{c,3,t}\right] + \left(\sum_{j=5}^{7} p_{(mf)}{}^{a}_{c,j,t}\right)\left[y^{a}_{c,5,t} - y^{a}_{c,3,t}\right] \\ ayss_{(f)}{}^{a}_{c,t} = p_{(f)}{}^{a}_{c,4,t}\left[y^{a}_{c,4,t} - y^{a}_{c,3,t}\right] + \left(\sum_{j=5}^{7} p_{(f)}{}^{a}_{c,j,t}\right)\left[y^{a}_{c,5,t} - y^{a}_{c,3,t}\right] \\ ayst_{(mf)}{}^{a}_{c,t} = p_{(mf)}{}^{a}_{c,6,t}\left[y^{a}_{c,6,t} - y^{a}_{c,5,t}\right] + p_{(mf)}{}^{a}_{c,7,t}\left[y^{a}_{c,7,t} - y^{a}_{c,5,t}\right] \\ ayst_{(f)}{}^{a}_{c,t} = p_{(f)}{}^{a}_{c,6,t}\left[y^{a}_{c,6,t} - y^{a}_{c,5,t}\right] + p_{(f)}{}^{a}_{c,7,t}\left[y^{a}_{c,7,t} - y^{a}_{c,5,t}\right] \\ y^{a}_{c,1,t} = 0 \end{cases}$$

Where:

[18] 146 countries for 13 age groups at 13 moments between 1950 and 2010 : 146*13*13=24674

- $aysp_{(mf)}{}^{a}_{c,t}$: Average years of schooling of primary cycle of the age group "a" of the country "c" in the total population at time "t".
- $ayss_{(mf)}{}^{a}_{c,t}$: Average years of schooling of secondary cycle of the age group "a" of the country "c" in the total population at time "t".
- $ayst_{(mf)}{}^{a}_{c,t}$: Average years of schooling of tertiary cycle of the age group "a" of the country "c" in the total population at time "t".
- $aysp_{(f)}{}^{a}_{c,t}$: Average years of schooling of primary cycle of the age group "a" of the country "c" in the women population at time "t".
- $ayss_{(f)}{}^{a}_{c,t}$: Average years of schooling of secondary cycle of the age group "a" of the country "c" in the women population at time "t".
- $ayst_{(f)}{}^{a}_{c,t}$: Average years of schooling of tertiary cycle of the age group "a" of the country "c" in the women population at time "t".
- $p_{(mf)}{}^{a}_{c,j,t}$: The fraction of the age group "a" of the country "c" in the total population having attained the educational level "j" at time "t".
- $p_{(f)}{}^{a}_{c,j,t}$: The fraction of the age group "a" of the country "c" in the women population having attained the educational level "j" at time "t".

The resolution of the system is:

$$
\begin{cases}
y^{a}_{c,1,t} = 0 \\
y^{a}_{c,2,t} = \dfrac{\left(\sum_{j=3}^{7} p_{(f)}{}^{a}_{c,j,t}\right)\left(aysp_{(mf)}{}^{a}_{c,t}\right) - \left(\sum_{j=3}^{7} p_{(mf)}{}^{a}_{c,j,t}\right)\left(aysp_{(f)}{}^{a}_{c,t}\right)}{p_{(mf)}{}^{a}_{c,2,t}\left(\sum_{j=3}^{7} p_{(f)}{}^{a}_{c,j,t}\right) - p_{(f)}{}^{a}_{c,2,t}\left(\sum_{j=3}^{7} p_{(mf)}{}^{a}_{c,j,t}\right)} \\
y^{a}_{c,3,t} = \dfrac{p_{(mf)}{}^{a}_{c,2,t}\left(aysp_{(f)}{}^{a}_{c,t}\right) - p_{(f)}{}^{a}_{c,2,t}\left(aysp_{(mf)}{}^{a}_{c,t}\right)}{p_{(mf)}{}^{a}_{c,2,t}\left(\sum_{j=3}^{7} p_{(f)}{}^{a}_{c,j,t}\right) - p_{(f)}{}^{a}_{c,2,t}\left(\sum_{j=3}^{7} p_{(mf)}{}^{a}_{c,j,t}\right)} \\
y^{a}_{c,4,t} = y^{a}_{c,3,t} + \dfrac{\left(\sum_{j=5}^{7} p_{(f)}{}^{a}_{c,j,t}\right)\left(ayss_{(mf)}{}^{a}_{c,t}\right) - \left(\sum_{j=5}^{7} p_{(mf)}{}^{a}_{c,j,t}\right)\left(ayss_{(f)}{}^{a}_{c,t}\right)}{p_{(mf)}{}^{a}_{c,4,t}\left(\sum_{j=5}^{7} p_{(f)}{}^{a}_{c,j,t}\right) - p_{(f)}{}^{a}_{c,4,t}\left(\sum_{j=5}^{7} p_{(mf)}{}^{a}_{c,j,t}\right)} \\
y^{a}_{c,5,t} = y^{a}_{c,3,t} + \dfrac{p_{(mf)}{}^{a}_{c,4,t}\left(ayss_{(f)}{}^{a}_{c,t}\right) - p_{(f)}{}^{a}_{c,4,t}\left(ayss_{(mf)}{}^{a}_{c,t}\right)}{p_{(mf)}{}^{a}_{c,4,t}\left(\sum_{j=5}^{7} p_{(f)}{}^{a}_{c,j,t}\right) - p_{(f)}{}^{a}_{c,4,t}\left(\sum_{j=5}^{7} p_{(mf)}{}^{a}_{c,j,t}\right)} \\
y^{a}_{c,6,t} = y^{a}_{c,5,t} + \dfrac{p_{(f)}{}^{a}_{c,7,t}\left(ayst_{(mf)}{}^{a}_{c,t}\right) - p_{(mf)}{}^{a}_{c,7,t}\left(ayst_{(f)}{}^{a}_{c,t}\right)}{p_{(mf)}{}^{a}_{c,6,t}\,p_{(f)}{}^{a}_{c,7,t} - p_{(f)}{}^{a}_{c,6,t}\,p_{(mf)}{}^{a}_{c,7,t}} \\
y^{a}_{c,7,t} = y^{a}_{c,5,t} + \dfrac{p_{(mf)}{}^{a}_{c,6,t}\left(ayst_{(f)}{}^{a}_{c,t}\right) - p_{(f)}{}^{a}_{c,6,t}\left(ayst_{(mf)}{}^{a}_{c,t}\right)}{p_{(mf)}{}^{a}_{c,6,t}\,p_{(f)}{}^{a}_{c,7,t} - p_{(f)}{}^{a}_{c,6,t}\,p_{(mf)}{}^{a}_{c,7,t}}
\end{cases}
$$

It should be noted that when the denominator is equal to zero we can obtain the value of $y^{a}_{j,t}$ by the following equation ($y^{a-1}_{j,t-5} = y^{a}_{j,t} = y^{a+1}_{j,t+5}$), because it is the same cohort who went through the same educational system.

V. Global Trends in Inequality in Educational Attainment

V.1 The evolution of inequality in education

The results show that educational inequality has been declining for all regions and for all age groups during the last six decades (Table A.3). However, it did not occur in a uniform manner because it depends on age groups, development levels, and gender. Indeed, the world Gini index of education decreased from 0.64 in 1950 to 0.34 in 2010 among the population aged 15 years and above; while it decreased from 0.56 to 0.24, in the same period, among young population aged 15 to 24 who benefited from significant progress of basic education between 1950 and 2010 (Figure A.1). Whereas, the Gini index of education for advanced countries decreased from 0.38 to 0.19, for developing countries it declined from 0.73 to 0.36. In fact, among the population aged 15 years and above, the level of educational inequality for advanced countries, registered in 1950, is equal to the one noted for developing countries in 2010. These results in a difference of 6 decades in terms of efforts allocated to reduce the educational inequality. The gap between developed and developing countries has narrowed by 20 years over the young population aged 15-24 (Table A.1).

The level of inequality is more pronounced in less developed countries in the 1950s, they are strongly lowered over the period. Even if in 2010 level remains higher than in developed countries. Education inequality declined for all age groups but this decline has been particularly strong for young people aged between 15 and 24 years old who have the most egalitarian distribution of education in 2010 (see Table A.1 and Figure A.1). In dynamics however, the degree of inequality decrease with age. Note that the decline in inequality in developing countries has been the highest among the 15-24 years. They benefited from the quantitative progress related to the development of basic education in last century.

The analysis of the educational inequality by gender shows a downward trend. It depends, however, on the development level and the geographical zones (Figure A.2). Indeed, developed countries reached gender parity and, similarly, in a lesser extent for the Latin America. In contrast, in developing countries, the distribution of education has changed reducing inequality in favor of men, who have a distribution of education relatively more equitable than women (Table A.2). Despite development of education in these countries in recent years, gender inequality remains pervasive during the period. In the

MENA region for example, inequalities between women register a slow decline. This denotes a certain process of convergence in relation to other regions such as South Asia and the Sub Saharian Africa.

In Figure A.5 we plotted the Education Lorenz curves of developed and developing countries by age. We constructed it by putting the cumulative proportion of population on the abscissa axis, and the cumulative proportion of schooling on ordered axis. A horizontal reading of the curves gives the evolution of educational inequality in the same age through time. A vertical reading of the curves reflects a cross-section difference over age group which shows differences between the levels of the educational inequality of different age groups. A diagonal reading allows us to see and track the evolution of inequality within the same cohort through time. A diagonal reading allows us to see and track the evolution of inequality in the same cohort over time. We can note for example that the level of inequality in the age group 15-24 has declined between 1950 and 2000 closer to that of developed countries. This reflects the advances in basic education for the young people especially during the last decades. As been said before; the degree of inequality is higher for upper age group. Indeed, trend is downward over the period 1950-2010 with maintaining inter-generational differences.

V.2 Average years of schooling and distribution of education

Londoño (1990); Ram (1990) and Thomas et al. (2001) show that the relationship between education inequality, measured in terms of standard deviation of schooling, and the level of education measured by the average years of schooling follows bell-shaped curve: during the development of education, the variance increase and then decrease. Some empirical works find that the standard deviation of schooling rise continuously with the increase of the average years of schooling to reach a certain peak at around 6-7 years of schooling, and then decline.

In the literature, the analysis of the relationship between the level and inequality of education brings additional lights to explain why in LDC's – despite the improvement of their educational system – the decline in income inequality appears to be insignificant. In fact, there is a strong correlation between the distribution of education and income (Fields, 1980). It is therefore interesting to evaluate the relationship between inequality and the average years of schooling and thus the turning point rich of information.

To do this, we calculate the standard deviation of schooling (proxy of inequality) given by:

$$SDS = \sqrt{\sum_{i=1}^{n} p_i (y_i - \mu)^2}$$

However, instead of using standard deviation of schooling in absolute value, Thomas et al. (2001) find a strong negative association on cross-country data between Gini Index of Education and average years of schooling. This suggests that countries which spend more resources for education are also those where the distribution of enrolment between individuals is the most equitable. Moving any person out of illiteracy should improve the distribution of education and at the same time the level of educational attainment.

Figure B.1 shows that the Gini index of education decline with the increase of the average levels of education. Countries with a high average of years of schooling are likely to know weak levels of inequalities. This trend is confirmed, as is the case in most of the empirical work, in our sample regardless of the region of the world.

Our data show that the relation between inequality in education, measured by a standard deviation of schooling, and the level of schooling follow a bell shape curve for the case of all selected regions (Figure B.2). As in previous empirical works, the turning point we estimated somewhere between seven years, beyond that, dispersion between individuals in education decline. Note that more the level of development is greater, the turning point is high. In fact generally the level of education of the population in developed countries is higher than in developing countries.

Conclusion

Research on inequalities in education is important both for political and empirical research. For public policy, it is a tool to assess the progress in educational development of a country. Important disparities in education can compromise the achievement of objectives related to the equality of opportunity. Furthermore, many recent empirical studies highlight the impact of the distributional dimension of human capital on economic growth and welfare.

This work is an extended research on the issue of measurement of inequality in education. We propose new data sets on educational inequality by the estimation of a Gini index specific to education covering the period 1950-2010. After a brief discussion of the empirical literature on the issue - more specifically the existing datasets - we have presented the data we use in the calculations and estimations, described the methodology and then illustrated some trends in the evolution of inequalities in the world.

Generally, existing data sets in educational inequality use a Gini index for the population aged 15 years and over based on the average year of schooling estimated from old version of Barro and Lee's datasets or using national Census of population. However, they do not involve the variability in cycles in their calculations between cohorts and time durations, which skews their estimates. Indeed, the population aged 15 years and over consisting of individuals who have not necessarily spent the same time in each cycle and did not go through the same school regime.

In this paper, we consider that the duration of school cycles is different from one country to another and even in the same country over time and among cohorts. Moreover – in addition to estimate a Gini index for each country – and instead of calculating an average of Gini by regions or a range of countries, we have computed a Gini index dealing with individual and temporal heterogeneity. These enable us to fully exploit the richness of the data disaggregated by age group.

The data reveal a decrease in inequality in the world for the whole period. Trends are however contrasted depending on the level of development and age group. Being more manifest in developing countries in the 1950s, Education inequality is strongly lowered over the period. Though, in 2010, level remains higher than advanced countries. Education inequality in developing countries was likely to be worse than one of the advanced countries. This seems to be supported by the results of the decomposition which show that inequalities between advanced countries and less developed countries explain 20.4 % in 2010 of the total inequality but decline over the period in favor of increased within inequalities.

Table A.1. Gini Education by age group, 1950-2010

Region/ Age group	1950	1970	1990	2010
World (146)				
15-24	0,56	0,44	0,34	0,24
25-34	0,66	0,51	0,40	0,29
35-44	0,67	0,58	0,45	0,33
45-54	0,67	0,64	0,52	0,37
55-64	0,68	0,65	0,59	0,41
65-74	0,66	0,64	0,63	0,47
75 and over	0,61	0,61	0,57	0,51
15+	0,64	0,55	0,45	0,34
Advanced Countries (24)				
15-24	0,34	0,27	0,22	0,16
25-34	0,35	0,30	0,21	0,15
35-44	0,37	0,34	0,24	0,17
45-54	0,38	0,34	0,29	0,18
55-64	0,40	0,36	0,34	0,20
65-74	0,40	0,39	0,37	0,25
75 and over	0,40	0,38	0,37	0,27
15+	0,38	0,33	0,28	0,19
Developing Countries (122)				
15-24	0,61	0,47	0,35	0,25
25-34	0,75	0,56	0,42	0,31
35-44	0,78	0,64	0,49	0,35
45-54	0,79	0,74	0,57	0,40
55-64	0,81	0,76	0,66	0,45
65-74	0,80	0,77	0,73	0,53
75 and over	0,77	0,76	0,70	0,63
15+	0,73	0,61	0,48	0,36

Source: Author's calculations based on Barro-Lee Data (2010)

$$Gini^{G}_{R,t} = \frac{\sum_{c\in R}\sum_{c'\in R}\sum_{a\in G}\sum_{a'\in G}\sum_{i=1}^{n}\sum_{j=1}^{n} p^{a}_{c,i,t} L^{a}_{c,t} \left| y^{a}_{c,i,t} - y^{a'}_{c',j,t} \right| p^{a'}_{c',j,t} L^{a'}_{c',t}}{2\times\left[\sum_{c\in R}\sum_{a\in G}\sum_{j=1}^{n} p^{g}_{e,j,t} L^{g}_{e,t} y^{g}_{e,j,t}\right]\left[\sum_{c\in R}\sum_{a\in G} L^{a}_{c,t}\right]}$$

With

"*a*" Age group; "*c*" Country; "*t*". Time. Age group "a" corresponds for a =1 to 15–19 age group, a =2 to 20–24 age group, a = A =13 to 75 and above, a=15+ to the population aged 15 and above and finally a=25+ to the population aged 25 and above. *n* is the number of levels of education which is equal in our study to 7 levels. *i* and *j* are educational levels. *j =1 for no formal education, j=2 for incomplete primary, j =3 for complete primary, j =4 for incomplete secondary, j =5 for complete secondary, j =6 for incomplete tertiary, j =7 for complete tertiary*. $p^{a}_{j,t}$ is the fraction of group "a" having attained the educational level "j" at time "t". $y^{a}_{j,t}$ is the number of years of schooling accumulated by group "*a*" to attained the educational level "*j*" at time "*t*".

Table A.2. Gini Education (population 15 age and over)
By region and sex, 1950-2010

Year	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010
World (146)													
Female	0,68	0,66	0,64	0,62	0,59	0,57	0,54	0,51	0,48	0,46	0,43	0,40	0,38
Male	0,60	0,58	0,57	0,54	0,51	0,48	0,45	0,43	0,41	0,37	0,34	0,31	0,30
Total	0,64	0,62	0,60	0,58	0,55	0,53	0,49	0,47	0,45	0,42	0,39	0,36	0,34
Advanced Countries (24)													
Female	0,38	0,38	0,37	0,35	0,34	0,33	0,31	0,30	0,29	0,27	0,24	0,21	0,20
Male	0,37	0,36	0,36	0,34	0,32	0,31	0,29	0,28	0,27	0,24	0,21	0,19	0,18
Total	0,38	0,37	0,36	0,35	0,33	0,32	0,30	0,29	0,28	0,25	0,23	0,20	0,19
Developing Countries (122)													
Female	0,78	0,76	0,74	0,70	0,66	0,63	0,59	0,56	0,52	0,49	0,47	0,43	0,41
Male	0,67	0,65	0,63	0,60	0,55	0,52	0,48	0,45	0,43	0,39	0,35	0,33	0,31
Total	0,73	0,71	0,68	0,65	0,61	0,58	0,54	0,50	0,48	0,44	0,41	0,38	0,36
By region													
East Asia and the Pacific (19)													
Female	0,83	0,79	0,74	0,68	0,60	0,54	0,49	0,45	0,43	0,40	0,37	0,34	0,31
Male	0,69	0,65	0,61	0,56	0,49	0,45	0,39	0,38	0,39	0,33	0,27	0,25	0,24
Total	0,76	0,72	0,68	0,62	0,55	0,50	0,44	0,42	0,41	0,36	0,32	0,29	0,27
Europe and Central Asia (20)													
Female	0,44	0,43	0,41	0,38	0,35	0,32	0,30	0,27	0,25	0,22	0,20	0,18	0,17
Male	0,38	0,36	0,34	0,32	0,28	0,26	0,22	0,21	0,19	0,18	0,16	0,15	0,15
Total	0,42	0,40	0,38	0,36	0,32	0,30	0,26	0,24	0,22	0,20	0,18	0,16	0,16
Latin America and the Caribbean (25)													
Female	0,65	0,63	0,60	0,58	0,55	0,54	0,52	0,47	0,44	0,40	0,37	0,33	0,31
Male	0,60	0,59	0,57	0,55	0,51	0,51	0,50	0,46	0,43	0,40	0,36	0,31	0,30
Total	0,62	0,61	0,59	0,56	0,53	0,53	0,51	0,46	0,43	0,40	0,36	0,32	0,31
Middle East and North Africa (18)													
Female	0,95	0,94	0,93	0,92	0,89	0,86	0,81	0,75	0,69	0,64	0,58	0,53	0,49
Male	0,89	0,87	0,85	0,81	0,77	0,72	0,65	0,57	0,52	0,49	0,45	0,42	0,38
Total	0,92	0,91	0,89	0,86	0,83	0,79	0,73	0,66	0,61	0,56	0,51	0,47	0,43
South Asia (7)													
Female	0,93	0,92	0,91	0,89	0,87	0,86	0,84	0,79	0,75	0,71	0,67	0,61	0,57
Male	0,74	0,73	0,72	0,72	0,68	0,66	0,64	0,58	0,52	0,49	0,45	0,41	0,37
Total	0,83	0,82	0,81	0,81	0,77	0,76	0,74	0,68	0,63	0,60	0,56	0,50	0,46
Sub-Saharan Africa (33)													
Female	0,89	0,88	0,87	0,85	0,82	0,79	0,75	0,71	0,66	0,61	0,60	0,57	0,54
Male	0,79	0,77	0,74	0,71	0,68	0,65	0,61	0,57	0,52	0,49	0,47	0,45	0,43
Total	0,84	0,83	0,81	0,78	0,76	0,72	0,68	0,64	0,59	0,55	0,54	0,51	0,49

Source: Author's calculations based on Barro-Lee Data (2010)

$$Gini^{G}_{R,t} = \frac{\sum_{c\in R}\sum_{c'\in R}\sum_{a\in G}\sum_{a'\in G}\sum_{i=1}^{n}\sum_{j=1}^{n} p^{a}_{c,i,t} L^{a}_{c,t} \left| y^{a}_{c,i,t} - y^{a'}_{c',j,t} \right| p^{a'}_{c',j,t} L^{a'}_{c',t}}{2\times\left[\sum_{c\in R}\sum_{a\in G}\sum_{j=1}^{n} p^{g}_{e,j,t} L^{g}_{e,t} y^{g}_{e,j,t}\right]\left[\sum_{c\in R}\sum_{a\in G} L^{a}_{c,t}\right]}$$

With

"*a*" Age group; "*c*" Country; "*t*". Time. Age group "a" corresponds for a =1 to 15–19 age group, a =2 to 20–24 age group, a = A =13 to 75 and above, a=15+ to the population aged 15 and above and finally a=25+ to the population aged 25 and above. *n* is the number of levels of education which is equal in our study to 7 levels. *i* and *j* are educational levels. *j =1 for no formal education, j=2 for incomplete primary, j =3 for complete primary, j =4 for incomplete secondary, j =5 for complete secondary, j =6 for incomplete tertiary, j =7 for complete tertiary*. $p^{a}_{j,t}$ is the fraction of group "a" having attained the educational level "j" at time "t". $y^{a}_{j,t}$ is the number of years of schooling accumulated by group "*a*" to attained the educational level "*j*" at time "*t*".

Table A.3. Gini Education by region, sex and age group 1950-2010

Year	1950			1970			1990			2010		
Sex	**Females**	**Males**	**Total**	**Females**	**Males**	**Total**	**Females**	**Males**	**Total**	**Females**	**Males**	**Total**
World (146)												
15-19	0,54	0,51	0,53	0,44	0,41	0,42	0,35	0,30	0,32	0,24	0,21	0,23
20-24	0,64	0,54	0,59	0,50	0,41	0,46	0,38	0,32	0,35	0,27	0,22	0,25
25-29	0,69	0,59	0,64	0,55	0,47	0,51	0,42	0,37	0,39	0,31	0,25	0,28
30-34	0,72	0,63	0,68	0,56	0,47	0,51	0,45	0,36	0,41	0,34	0,27	0,31
35-39	0,71	0,64	0,68	0,62	0,54	0,58	0,48	0,42	0,45	0,37	0,30	0,33
40-44	0,70	0,63	0,67	0,63	0,53	0,58	0,50	0,42	0,46	0,38	0,30	0,34
45-49	0,71	0,64	0,67	0,67	0,57	0,62	0,55	0,49	0,52	0,40	0,31	0,35
50-54	0,70	0,64	0,67	0,70	0,62	0,66	0,57	0,48	0,52	0,43	0,34	0,39
55-59	0,71	0,65	0,68	0,68	0,61	0,65	0,63	0,54	0,59	0,45	0,35	0,40
60-64	0,71	0,64	0,68	0,68	0,60	0,64	0,63	0,57	0,60	0,48	0,37	0,43
65-69	0,70	0,62	0,67	0,67	0,61	0,64	0,65	0,59	0,63	0,52	0,40	0,46
70-74	0,68	0,60	0,65	0,65	0,59	0,62	0,66	0,59	0,63	0,54	0,42	0,48
75 and over	0,64	0,56	0,61	0,62	0,59	0,61	0,59	0,54	0,57	0,56	0,45	0,51
Advanced Countries (24)												
15-19	0,35	0,32	0,33	0,25	0,25	0,25	0,21	0,23	0,22	0,16	0,16	0,16
20-24	0,34	0,34	0,34	0,27	0,26	0,27	0,19	0,18	0,19	0,13	0,12	0,13
25-29	0,36	0,34	0,35	0,30	0,29	0,29	0,21	0,20	0,20	0,15	0,14	0,14
30-34	0,35	0,34	0,34	0,31	0,30	0,31	0,21	0,21	0,21	0,16	0,16	0,16
35-39	0,37	0,37	0,37	0,34	0,33	0,34	0,24	0,23	0,23	0,17	0,17	0,17
40-44	0,38	0,37	0,37	0,34	0,33	0,33	0,25	0,24	0,24	0,18	0,17	0,17
45-49	0,39	0,38	0,38	0,35	0,33	0,34	0,29	0,27	0,28	0,17	0,17	0,17
50-54	0,39	0,38	0,38	0,33	0,32	0,33	0,32	0,30	0,31	0,19	0,18	0,19
55-59	0,41	0,38	0,40	0,37	0,35	0,36	0,35	0,33	0,34	0,20	0,18	0,19
60-64	0,41	0,38	0,40	0,37	0,36	0,36	0,35	0,34	0,35	0,23	0,21	0,22
65-69	0,41	0,39	0,40	0,40	0,39	0,39	0,37	0,37	0,37	0,24	0,22	0,24
70-74	0,41	0,39	0,40	0,39	0,38	0,39	0,36	0,36	0,36	0,28	0,25	0,27
75 and over	0,41	0,39	0,40	0,38	0,37	0,38	0,37	0,37	0,37	0,28	0,26	0,27
Developing Countries (122)												
15-19	0,58	0,56	0,57	0,47	0,44	0,45	0,37	0,30	0,33	0,25	0,22	0,23
20-24	0,72	0,58	0,65	0,54	0,43	0,49	0,40	0,34	0,37	0,29	0,23	0,25
25-29	0,80	0,65	0,73	0,60	0,50	0,55	0,45	0,39	0,42	0,33	0,26	0,29
30-34	0,84	0,71	0,77	0,62	0,50	0,56	0,48	0,38	0,43	0,36	0,28	0,32
35-39	0,83	0,73	0,78	0,69	0,58	0,64	0,51	0,44	0,48	0,39	0,31	0,35
40-44	0,83	0,73	0,78	0,71	0,58	0,64	0,55	0,45	0,50	0,41	0,31	0,36
45-49	0,83	0,74	0,79	0,79	0,64	0,72	0,61	0,54	0,58	0,43	0,33	0,38
50-54	0,85	0,75	0,80	0,83	0,70	0,77	0,63	0,51	0,57	0,47	0,36	0,42
55-59	0,86	0,76	0,81	0,81	0,71	0,76	0,70	0,59	0,65	0,50	0,37	0,43
60-64	0,86	0,76	0,81	0,81	0,71	0,76	0,72	0,63	0,68	0,54	0,40	0,47
65-69	0,86	0,75	0,81	0,81	0,71	0,77	0,76	0,67	0,72	0,59	0,43	0,52
70-74	0,84	0,74	0,80	0,81	0,70	0,76	0,80	0,67	0,74	0,62	0,46	0,55
75 and over	0,80	0,70	0,77	0,80	0,71	0,76	0,75	0,63	0,70	0,71	0,52	0,63
East Asia and the Pacific (19)												
15-19	0,39	0,44	0,43	0,29	0,37	0,33	0,24	0,24	0,24	0,13	0,14	0,13
20-24	0,70	0,52	0,61	0,36	0,28	0,33	0,26	0,27	0,27	0,15	0,16	0,15
25-29	0,88	0,63	0,75	0,42	0,38	0,41	0,29	0,31	0,30	0,18	0,16	0,17
30-34	0,93	0,73	0,83	0,49	0,37	0,43	0,34	0,28	0,31	0,23	0,20	0,21
35-39	0,95	0,80	0,87	0,60	0,52	0,57	0,38	0,39	0,39	0,25	0,20	0,23
40-44	0,95	0,80	0,87	0,69	0,51	0,60	0,40	0,37	0,39	0,27	0,21	0,24
45-49	0,95	0,81	0,88	0,88	0,62	0,75	0,48	0,53	0,51	0,29	0,22	0,26
50-54	0,95	0,81	0,88	0,92	0,72	0,82	0,55	0,47	0,52	0,34	0,25	0,29
55-59	0,96	0,82	0,89	0,94	0,78	0,86	0,68	0,61	0,66	0,38	0,26	0,32
60-64	0,96	0,82	0,89	0,95	0,78	0,87	0,75	0,67	0,72	0,41	0,28	0,35
65-69	0,97	0,81	0,90	0,96	0,79	0,88	0,86	0,73	0,79	0,48	0,31	0,41
70-74	0,97	0,80	0,90	0,95	0,78	0,88	0,88	0,70	0,80	0,57	0,36	0,47
75 and over	0,97	0,78	0,90	0,96	0,79	0,89	0,88	0,66	0,79	0,77	0,48	0,65

Year	1950			1970			1990			2010		
Sex	**Females**	**Males**	**Total**	**Females**	**Males**	**Total**	**Females**	**Males**	**Total**	**Females**	**Males**	**Total**
Europe and Central Asia (20)												
15-19	0,33	0,33	0,33	0,15	0,18	0,17	0,15	0,15	0,15	0,21	0,21	0,21
20-24	0,33	0,30	0,31	0,16	0,16	0,16	0,10	0,09	0,09	0,16	0,15	0,15
25-29	0,39	0,33	0,36	0,20	0,19	0,19	0,11	0,10	0,10	0,14	0,12	0,13
30-34	0,45	0,37	0,42	0,26	0,25	0,26	0,13	0,12	0,13	0,12	0,11	0,11
35-39	0,46	0,39	0,44	0,30	0,28	0,29	0,15	0,14	0,15	0,12	0,11	0,11
40-44	0,46	0,39	0,44	0,33	0,30	0,32	0,15	0,15	0,15	0,11	0,10	0,10
45-49	0,47	0,40	0,44	0,37	0,33	0,35	0,22	0,21	0,22	0,10	0,10	0,10
50-54	0,48	0,41	0,46	0,45	0,35	0,41	0,23	0,21	0,22	0,13	0,12	0,13
55-59	0,48	0,41	0,45	0,47	0,38	0,44	0,32	0,28	0,30	0,14	0,14	0,14
60-64	0,51	0,42	0,48	0,46	0,39	0,44	0,34	0,30	0,32	0,14	0,14	0,14
65-69	0,50	0,41	0,47	0,48	0,39	0,45	0,42	0,34	0,39	0,20	0,19	0,20
70-74	0,50	0,40	0,47	0,48	0,39	0,45	0,47	0,36	0,44	0,21	0,19	0,21
75 and over	0,50	0,39	0,47	0,49	0,39	0,47	0,47	0,34	0,44	0,34	0,25	0,31
Latin America and the Caribbean (25)												
15-19	0,60	0,58	0,59	0,46	0,42	0,44	0,11	0,26	0,27	0,21	0,23	0,22
20-24	0,62	0,59	0,60	0,50	0,48	0,49	0,16	0,34	0,32	0,17	0,18	0,18
25-29	0,64	0,60	0,62	0,54	0,50	0,52	0,27	0,45	0,42	0,21	0,20	0,21
30-34	0,63	0,60	0,62	0,54	0,52	0,53	0,28	0,42	0,42	0,24	0,24	0,24
35-39	0,64	0,60	0,62	0,57	0,53	0,55	0,33	0,44	0,45	0,27	0,27	0,27
40-44	0,66	0,60	0,63	0,59	0,54	0,57	0,37	0,46	0,47	0,30	0,29	0,29
45-49	0,67	0,61	0,64	0,61	0,56	0,58	0,45	0,49	0,51	0,35	0,34	0,34
50-54	0,69	0,62	0,66	0,61	0,56	0,58	0,48	0,51	0,53	0,41	0,39	0,40
55-59	0,70	0,63	0,67	0,63	0,58	0,60	0,53	0,52	0,54	0,41	0,39	0,40
60-64	0,71	0,63	0,67	0,63	0,58	0,60	0,59	0,55	0,57	0,49	0,46	0,48
65-69	0,71	0,65	0,68	0,65	0,60	0,63	0,66	0,58	0,59	0,50	0,46	0,48
70-74	0,72	0,66	0,69	0,65	0,60	0,63	0,64	0,57	0,59	0,54	0,51	0,52
75 and over	0,71	0,65	0,68	0,65	0,60	0,62	0,66	0,58	0,59	0,57	0,54	0,56
Middle East and North Africa (18)												
15-19	0,91	0,85	0,88	0,76	0,61	0,68	0,47	0,35	0,40	0,28	0,28	0,28
20-24	0,95	0,87	0,91	0,85	0,67	0,76	0,55	0,38	0,45	0,34	0,30	0,32
25-29	0,95	0,87	0,91	0,89	0,73	0,81	0,62	0,43	0,52	0,36	0,31	0,33
30-34	0,96	0,89	0,92	0,92	0,79	0,86	0,71	0,52	0,61	0,41	0,34	0,36
35-39	0,95	0,89	0,92	0,94	0,82	0,88	0,76	0,55	0,65	0,47	0,36	0,41
40-44	0,96	0,90	0,93	0,95	0,85	0,90	0,83	0,63	0,73	0,55	0,38	0,46
45-49	0,96	0,91	0,94	0,95	0,86	0,90	0,87	0,69	0,78	0,61	0,43	0,52
50-54	0,96	0,92	0,94	0,96	0,88	0,92	0,91	0,74	0,83	0,71	0,51	0,61
55-59	0,96	0,92	0,94	0,95	0,88	0,91	0,92	0,77	0,84	0,75	0,54	0,65
60-64	0,96	0,93	0,94	0,96	0,90	0,93	0,93	0,80	0,86	0,82	0,61	0,72
65-69	0,96	0,93	0,95	0,96	0,91	0,94	0,92	0,80	0,86	0,86	0,67	0,77
70-74	0,96	0,93	0,94	0,97	0,91	0,94	0,93	0,83	0,88	0,90	0,71	0,81
75 and over	0,96	0,93	0,95	0,96	0,91	0,94	0,91	0,81	0,87	0,89	0,72	0,81
South Asia (7)												
15-19	0,86	0,67	0,76	0,74	0,53	0,63	0,55	0,37	0,45	0,26	0,15	0,20
20-24	0,91	0,72	0,81	0,82	0,60	0,71	0,66	0,43	0,54	0,38	0,21	0,29
25-29	0,93	0,73	0,83	0,88	0,68	0,78	0,72	0,49	0,60	0,49	0,31	0,39
30-34	0,93	0,73	0,83	0,88	0,69	0,78	0,75	0,52	0,63	0,55	0,34	0,44
35-39	0,95	0,76	0,85	0,93	0,75	0,84	0,77	0,54	0,65	0,62	0,43	0,52
40-44	0,95	0,76	0,85	0,93	0,75	0,84	0,81	0,57	0,69	0,66	0,43	0,54
45-49	0,95	0,76	0,85	0,93	0,75	0,84	0,85	0,60	0,72	0,71	0,48	0,59
50-54	0,96	0,80	0,88	0,93	0,75	0,84	0,87	0,64	0,76	0,74	0,50	0,62
55-59	0,96	0,80	0,88	0,93	0,76	0,84	0,88	0,66	0,77	0,76	0,52	0,64
60-64	0,96	0,80	0,88	0,93	0,76	0,84	0,91	0,72	0,81	0,80	0,55	0,67
65-69	0,96	0,78	0,88	0,93	0,76	0,84	0,90	0,70	0,80	0,83	0,57	0,71
70-74	0,96	0,79	0,88	0,93	0,75	0,84	0,91	0,72	0,82	0,85	0,61	0,74
75 and over	0,96	0,79	0,88	0,93	0,76	0,84	0,91	0,71	0,81	0,86	0,61	0,75

Year	1950			1970			1990			2010		
Sex	**Females**	**Males**	**Total**	**Females**	**Males**	**Total**	**Females**	**Males**	**Total**	**Females**	**Males**	**Total**
Sub-Saharan Africa (33)												
15-19	0,83	0,72	0,78	0,69	0,55	0,62	0,50	0,41	0,45	0,40	0,35	0,38
20-24	0,88	0,74	0,81	0,78	0,63	0,70	0,54	0,42	0,48	0,47	0,38	0,42
25-29	0,89	0,78	0,83	0,82	0,66	0,74	0,60	0,46	0,53	0,50	0,40	0,45
30-34	0,89	0,79	0,84	0,83	0,68	0,76	0,64	0,51	0,58	0,52	0,42	0,47
35-39	0,90	0,81	0,86	0,87	0,71	0,79	0,71	0,56	0,64	0,54	0,42	0,48
40-44	0,90	0,83	0,87	0,88	0,74	0,81	0,76	0,60	0,68	0,56	0,42	0,49
45-49	0,91	0,84	0,88	0,89	0,78	0,84	0,81	0,64	0,73	0,62	0,47	0,55
50-54	0,91	0,85	0,88	0,90	0,80	0,85	0,82	0,66	0,74	0,65	0,51	0,58
55-59	0,92	0,85	0,89	0,90	0,81	0,86	0,85	0,69	0,77	0,72	0,57	0,65
60-64	0,92	0,85	0,89	0,90	0,83	0,87	0,87	0,72	0,80	0,76	0,60	0,69
65-69	0,92	0,85	0,89	0,92	0,84	0,88	0,87	0,75	0,82	0,81	0,65	0,74
70-74	0,92	0,85	0,89	0,91	0,85	0,88	0,88	0,77	0,83	0,82	0,66	0,75
75 and over	0,93	0,86	0,90	0,90	0,84	0,88	0,87	0,77	0,83	0,83	0,69	0,77

Source: Author's calculations based on Barro-Lee Data (2010)

$$Gini^{a}_{R,t} = \frac{\sum_{c\in R}\sum_{c'\in R}\sum_{i=1}^{n}\sum_{j=1}^{n} p^{a}_{c,i,t} L^{a}_{c,t} \left| y^{a}_{c,i,t} - y^{a}_{c',j,t} \right| p^{a}_{c',j,t} L^{a}_{c',t}}{2\times\left[\sum_{c\in R}\sum_{j=1}^{n} p^{a}_{c,j,t} L^{a}_{c,t} y^{a}_{c,j,t}\right]\left[\sum_{c\in R} L^{a}_{c,t}\right]}$$

With

"*a*" Age group; "*c*" Country; "*t*". Time. Age group "a" corresponds for a =1 to 15–19 age group, a =2 to 20–24 age group, a = A =13 to 75 and above, a=15+ to the population aged 15 and above and finally a=25+ to the population aged 25 and above. *n* is the number of levels of education which is equal in our study to 7 levels. *i* and *j* are educational levels. *j =1 for no formal education, j=2 for incomplete primary, j =3 for complete primary, j =4 for incomplete secondary, j =5 for complete secondary, j =6 for incomplete tertiary, j =7 for complete tertiary*. $p^{a}_{j,t}$ is the fraction of group "a" having attained the educational level "j" at time "t". $y^{a}_{j,t}$ is the number of years of schooling accumulated by group "*a*" to attained the educational level "*j*" at time "*t*".

Figure.A.1. Gini Education by age group

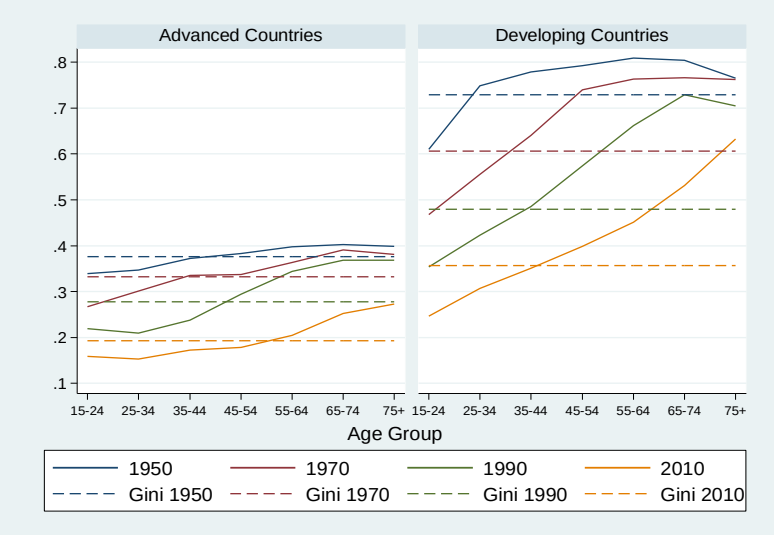


Figure.A.2. Gini Education by region and gender

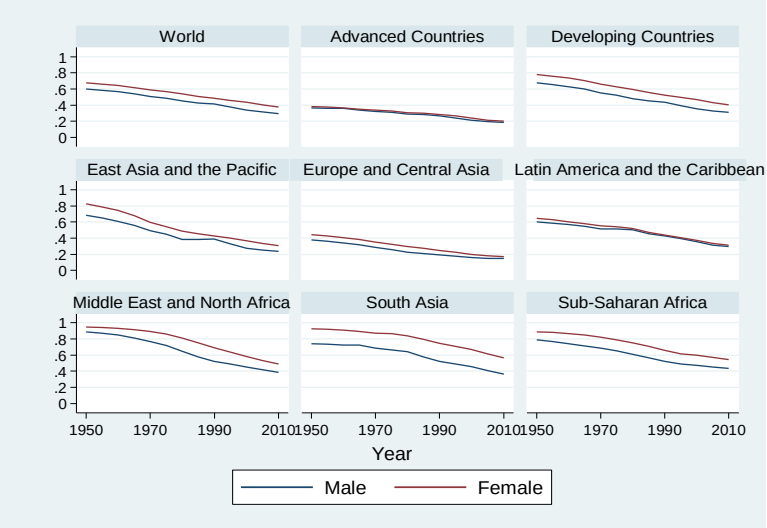


Figure.A.3. Gini Education by region

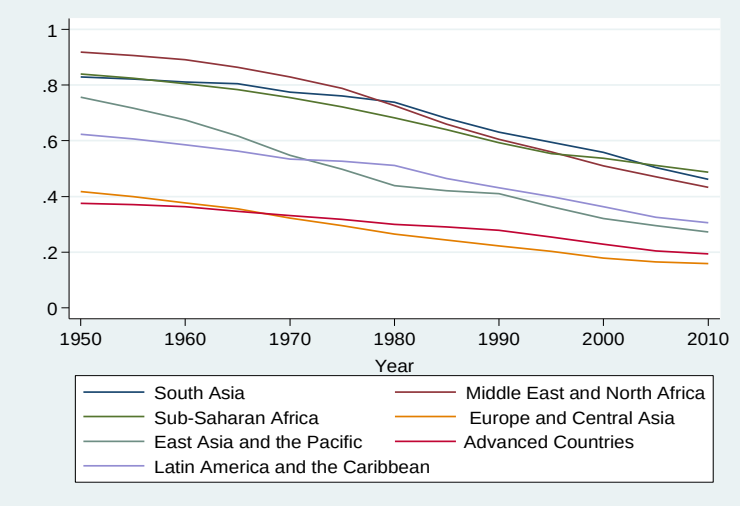


Figure.A.4. Education Lorenz Curve of the population aged over fifteen by development level

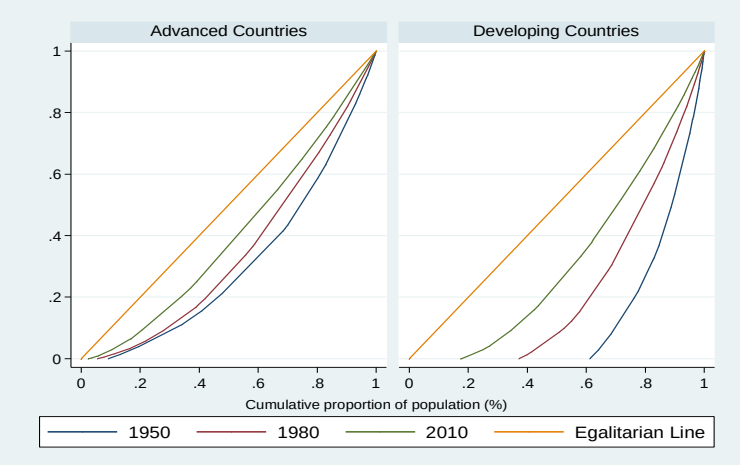
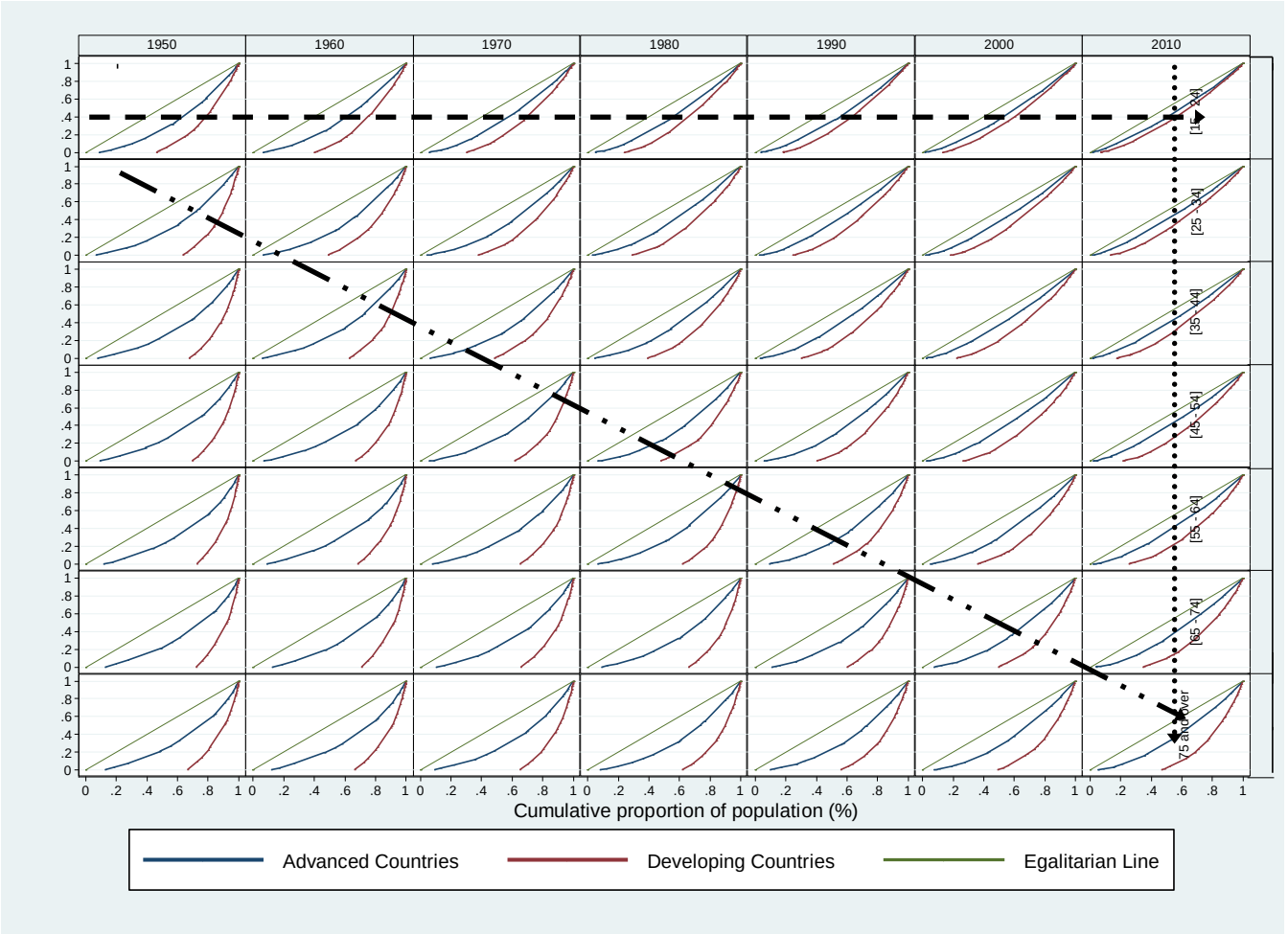


Figure.A.5. Education Lorenz Curve by age group and development level from 1950 to 2010



The evolution over time of the Education Lorenz Curve of the same age group

The evolution over time of Education Lorenz Curve of the same cohort

A cross-section Education Lorenz Curve over age group

Figure.B.1 Relationship between Gini index of Education and Average years of schooling by region

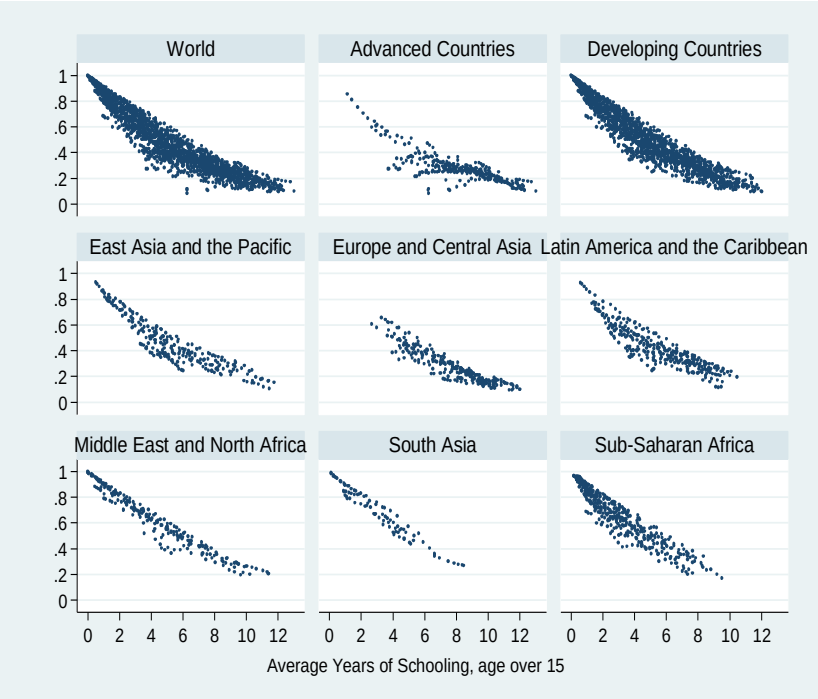
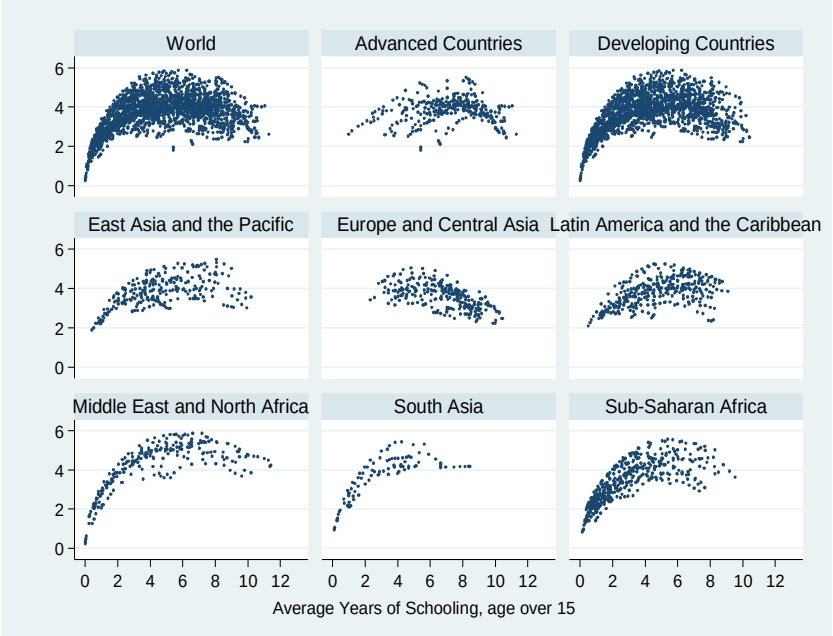


Figure.B.2 Relationship between standard deviation of schooling and average years of schooling: Education Kuznets Curve by region



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