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Monitoring Basic Opportunities throughout the Lifecycle with the Human Opportunity Index in Chile

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ACRONYMS AND ABBREVIATIONS

CASEN	Encuesta de Calidad de Vida de los Hogares
ELPI	Encuesta Longitudinal de Primera Infancia
ENJ	Encuesta Nacional de Juventud
HOI	Human Opportunity Index
LAC	Latin America and Caribbean
MIDEPLAN	Chilean Ministry of Planning
OECD	Organization for Economic Co-operation and Development
SIMCE	Sistema de Medicion de Calidad de la Educacion

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EXECUTIVE SUMMARY

Chile has made significant progress towards equalizing opportunities in recent years, especially those pertaining to poverty alleviation, school enrollment, and access to health services. However, there still remain significant gaps across socio-economic groups in access to other key opportunities such as adequate early childhood vocabulary, pre-school attendance, adequate math and reading, completion of secondary on time, access to some tertiary education, housing with adequate materials, and access to computer and internet. Reducing these gaps is a priority for Chile, an OECD country which has an ambitious social development agenda.

A monitoring system of basic opportunities that effectively incorporates equity concerns may help policymakers to design better policies for vulnerable groups in Chile. Introducing equity concerns with the Human Opportunity Index (HOI) across key opportunities spanning early childhood to adulthood may be an important initial step for mainstreaming equity in tracking the opportunities for human capital accumulation that will allow individuals to display their full potential later in life.

The HOI is an equality of opportunity adjusted coverage rate. The HOI provides a tractable way, in a single indicator, to measure progress toward universal coverage of opportunities as well as equitable access to those opportunities. It is the coverage rate of a given service minus a penalty for inequality of opportunity. Inequality of opportunity exists if access to important things in life is differentially associated to circumstances that lie outside the control of individuals and that society deemed as unfair sources of exclusion. Circumstances commonly used in inequality of opportunity analyses include gender, race, parental socio-economic status, location and family structure where a child is raised. The penalty for inequality of opportunity used in the HOI is estimated based on the access gap for the different circumstance groups. A circumstance group is a group whose members share the same circumstances. The HOI is interpreted as the proportion of basic opportunities required for universal coverage that are available and allocated according to the equality of opportunity principle.

Along with being a simple, intuitive and tractable measure, the HOI also satisfies several properties deemed desirable for an equity measure. Any increase in the amount of opportunities will improve the HOI despite to whom it is allocated. It is pro-vulnerable because if the coverage rate of a vulnerable group increases holding the overall coverage rate constant, the HOI also increases. Similarly, for a given expansion of available services, the HOI increases more if the extra units of services are allocated to a vulnerable group. In general the HOI ranges from 0 to 100.

The Government of Chile is currently pursuing integrated social protection packages through programs such as *Chile Crece Contigo* and *Chile Solidario* aimed at addressing the needs of vulnerable circumstance groups. These programs provide integrated support in the areas of health, early childhood development, education, family and community living conditions, as well as adequate housing and community infrastructure services. The Ministry of Social Development (former Ministry of Planning, MIDEPLAN) coordinates these integrated

social programs. The objective of this report is to propose how the HOI can be used to mainstream equity in a social monitoring system aimed at overcoming unequal opportunities. In this context, this study is an assessment of the equitable access to key services and living conditions that are important steps for effectively accumulating human capital and allowing citizens to lead a dignified life of their choosing. Ensuring children and youth have access to key services and basic outcomes (such as education, healthcare, adequate nutrition and clean water) regardless of their socio-economic status at birth are thought to be pre-conditions for Chileans to display their full potential.

The HOI indicators used in this report fall under the following five categories: (i) early childhood development, (ii) adequate learning, (iii) youth development, (iv)adequate housing and (v) basic opportunities for adults. The five circumstances along the lines of which we study inequality of opportunity are gender, location, ethnicity of the child, parent's level of education and the family structure. The dimensions, circumstances and indicators have been selected jointly with representatives of the Chilean Ministry of Social Development (former MIDEPLAN). Most of the indicators broadly correspond to the various schemes (such as the Chile Crece Contigo and Chile Solidario) which operate under the coordination of former MIDEPLAN. Four different datasets are used in this monitoring exercise. These datasets are the Encuesta Longitudinal de Primera Infancia-ELPI, the Encuesta Nacional de Juventud-ENJ, the Encuesta de Calidad de Vida de los Hogares-CASEN, and test scores from the Sistema de Medicion de Calidad de la Educacion-SIMCE.

The three main findings that emerge from this initial monitoring exercise are: (i) Chile does well in providing fundamental basic opportunities, but not as well on more advanced indicators such as quality learning, completion of secondary on time, access to some tertiary education, as well as bundles of services for early childhood development, and youth development; (ii) inequality of opportunity in Chile operates mainly on the basis of parental education and location, and (iii) a sound monitoring system of the equitable provision of opportunities for all may help the Chilean society strengthen consensus towards equity and provide policymakers with the right incentives to design and implement better policies to address these issues.

I. INTRODUCTION

The Chilean Ministry of Social Development (former MIDEPLAN) has a leading role in the implementation of the *Intersectoral Social Protection System* created in 2009 (Law 20379). This system seeks an integrated and coordinated approach to service delivery by several State institutions to the most vulnerable populations. Based on the principle that human development, especially child development, is multidimensional, and includes biological, physical, psychological, and social dimensions, the Ministry of Social Development seeks to effectively coordinate, monitor and evaluate decentralized state actions towards promoting human development.

The World Bank and the Ministry of Social Development (former MIDEPLAN) agreed to collaborate on building a social monitoring system aimed at promoting social mobility and equal opportunities. *Social mobility* is generally defined as movements in socio-economic status indicators by specific entities between periods (Behrman, 2000). There are a wide range of existing indicators of social mobility. Fields (2000:102) points out that "any aspect of economic well-being can be used". Similarly, Behrman (2000:73) states that "socio-economic status indicators that are most commonly used in empirical studies of social mobility include income, earnings, occupation, education, nature of marital matches, political participation, social participation, and social status measures". *Equality of opportunity* refers to the prospects of progressing in life based on one's effort and decisions without any bearing of family background, race, gender, place of birth, or other exogenous characteristics that a person cannot be held accountable for and society consider it should not matter for advancing in life.

This study is a monitoring exercise of equitable access to key services and living conditions that are important steps towards achieving social mobility. The study monitors access to key services and living conditions that are important elements in the process of human capital investment. Ensuring children and youth have access to key services and basic outcomes (such as education, healthcare, adequate nutrition and clean water) regardless of their socio-economic status at birth are thought to be necessary conditions for increasing social mobility. This study aims to support the Mionistry of Social Development's monitoring effort of the Intersectoral Social Protection System by including equality of opportunity adjusted indicators for key milestones of social mobility.

This assessment of the milestones for a hypothetical human capital investment process is done using the Human Opportunity Index (HOI). The HOI is an equality of opportunity adjusted coverage rate. The HOI is the coverage rate minus a penalty for inequality of opportunity. It allows a simultaneous consideration of the overall access and the allocation from an equality of opportunity perspective. The HOI estimates how personal circumstances for which an individual cannot be held accountable—such as race, gender, where they were raised or socioeconomic background—affect the probability of accessing basic services and outcomes that are necessary to develop one's own potential. In a single measure, the HOI combines both the progress toward providing universal coverage of basic opportunities (services and minimum outcomes) and how equitably these basic opportunities are distributed. The HOI helps policymakers pursue the dual goals of expanding basic opportunities and improving equality of opportunity for all individuals, regardless of their background at birth.

The ex-ante building blocks needed to promote human capital accumulation are grouped into five broad dimensions of basic opportunities: (i) early childhood development, (ii) adequate learning, (iii) youth development, (iv) adequate housing and (v) basic opportunities for adults that include living out of poverty and vulnerability and access to some tertiary education. These five dimensions are comprised of 28 indicators. These indicators have been jointly selected with representatives of the Ministry of Social Development (former MIDEPLAN). The indicators correspond to the various objectives of the Intersectoral Social Protection System. For each indicator the HOI with its corresponding coverage rate and penalty for inequality of opportunity will be reported.

Four datasets were used in this monitoring exercise. They include: the *Encuesta Longitudinal de Primera Infancia*-ELPI, the *Encuesta Nacional de Juventud*-ENJ, the *Encuesta de Calidad de Vida de los Hogares*-CASEN, and test scores from the *Sistema de Medicion de Calidad de la Educacion*-SIMCE. Using these datasets, we have analyzed basic opportunities during the life cycle of Chileans, from early childhood to adulthood, capturing both access to basic services and minimum outcome indicators which potentially form the stepping stones towards higher social mobility in the future.

Box 1: A Tale of Inequality of Opportunity (Based on True Chilean Data)

Consider the hypothetical case of two children born in December 2009 in Chile. In an equal opportunity society, based on their parental background and place of birth, their chances to achieve social and economic success in life should not be different. However, the fact is that currently they *are very different*. Take the case of Patricio, who (imagine) was born in rural Loncoche to parents that did not complete primary school. Also, consider Christian, who (assume) was born at the same time in la Condes, Metropolitan Santiago to parents with some tertiary education. It turns out that the probability that Christian attends pre-school at ages 3-5 is more than double that of Patricio's. Similarly, Christian's chances with respect to Patricio's are twice as high for having adequate toys during his toddler years. Relative to Patricio, Christian has a 58 percent higher chance of having adequate vocabulary at age 5 and is more than twice as likely to complete secondary school on time. Regarding quality of learning (based on SIMCE scores) in the 4th grade, the probability of Christian reaching at least the intermediate level is 40 percent higher for reading and 51 percent for math relative to Patricio. Moreover, this difference will *increase* by the time they reach 8th grade.

Christian has higher chances than Patricio of living in a house with adequate materials (76 percent higher), adequate water (25 percent), sanitation (67 percent), access to a computer (more than 3 times as likely), and internet (more than 4 times as likely). The chance that Christian actively participates in the political process is 64 percent higher than that of Patricio's. Christian's chances to acquire some tertiary education are 8 times higher than Patricio's. As a result of the differences in access to opportunities during the initial stages of human capital accumulation, Christian's chances of living as an adult in a household with at least US$ 10 a day per person -- the Latin American middle class -- is more than twice that of Patricio's.

Source: Authors' calculations using the four different datasets listed above: ELPI, CASEN, ENJ, and SIMCE**.**

Table 1: Milestones of a Hypothetical Life-cycle Human Capital Investment Process

ADEQUATE HOUSING	
Adequate water	Access to running water
Adequate sanitation	Access to public sysytem
Adequate Housing materials	Appropriate material for floor, walls and ceiling
Access to computer	Has computer in household
Access to internet	Has internet in household
EARLY CHILDHOOD DEVELOPMENT	
Parents involved with child	Either Parent read to the child and did atleast 4 out of 5 activities listed
Adequate toys	The child had adequates toys and reading tools.
Attends pre-school	Children between ages 3 to 5 attend pre-school
Adequate socio-emotional development	Assess emotional reactivity, anxiaty/depression, attention deficit, aggresivity, autism, sleep disorder. Children from 18 to 35 months using a CBCL test.
Adequate psychomotor development	Assess manual coordination, language development, and own body motaricity with respect to the statistical standard for own age. Children from 2 to 5 years old using TEPSI test.
Adequate vocabulary	Psycometric test that assess the receptive and auditive vocabulary. Spanish adaptation of the Peabody images test (TVIP)
Adequate height-for-age	Child has normal height for age
Normal birth weight	The child had a birthweight between 2.5 to 4 Kg.
ADEQUATE EDUCATION	
Enrollment (Ages 7-16)	Attends to school. Ages 7-16
Completed grade 12 on time	Completed 12th grade on time by age 18
Adequate reading in grade 4	Reaches al least an intermediate level of reading in SIMCE test in grade 4
Adequate math in grade 4	Reaches al least an intermediate level of math in SIMCE test in grade 4
Adequate reading in grade 8	Reaches al least an intermediate level of reading in SIMCE test in grade 8
Adequate math in grade 8	Reaches al least an intermediate level of math in SIMCE test in grade 8
YOUTH DEVELOPMENT	
Read	Read books, newspapers, etc. at least once a week
Participate in the political process	For 18 years and over, if they participate in politcal discussions, rallies, etc.
Play sports	Play sports at least once a week
Free from illegal consumption	Free from consumption of illegal substances regularly
Safe sexual practices	No sexually active or if sexually active practice safe sex
BASIC OPPORTUNITIES FOR ADULTS	
Access to tertiary education	Has 13 or more years of education
No extreme poverty (US$ 1.25/day)	Has an income equal to or above US$ 1.25 a day per capita
No poverty (US$ 4/day)	Has an income equal to or above US$ 4 a day per capita
LAC Middle Class (US$ 10/day)	Has an income equal to or above US$ 1.25 a day per capita

In this monitoring exercise we observe a mixed picture. Chile does well in providing access to basic opportunities such as adequate nutrition, psychomotor development at early childhood, access to water and sanitation, school enrollment, support for keeping their youth free from consumption of illegal substances, and keeping their population out of poverty. However, there still are significant challenges to level the playing field in several important fronts, such as the quality of education, learning outcomes, youth literacy rates, participation in the political process, and access to a computer, the internet, and tertiary education.

When considering access to a bundle of services rather than individual indicators the levels of deprivation and inequality of opportunity seem more acute. For example, despite high individual HOIs for adequate vocabulary (74), adequate socio-emotional development (79) and adequate psychomotor development (88), when the opportunity is defined as access to the complete package for early childhood development (requiring having simultaneous access to adequate levels in the three indicators) the HOI for the package of early childhood development is only 35. The HOI for a package of adequate learning (requiring having simultaneously adequate reading and math) in grade 8 is only 36. For the package youth development, the HOI is only 11, contrasting with the single HOI for each of the three comprising indicator that range from 52 (participation in the political process), 75 (safe sexual practices) to 92 (free from illegal consumption). Finally, for core housing package, the HOI is 75, lower than each of the three comprising indicator that range from 79 (adequate housing material), 93 (adequate sanitation) to 97 (adequate water).

Inequality of opportunity in Chile is mostly a result of parental education and location where raised as child. The five circumstances over which inequality of opportunity were analyzed includes: gender, location where raised as child, ethnicity of the child, parent's level of education and the family structure. Circumstances are factors over which individuals cannot be held accountable for and society does not want to be related to progress in life. Parent's educational background is the most salient circumstance among the five circumstances considered for 24 of the 28 basic opportunities studied. Location is the second most important circumstance over which exclusion operates. Location is either the most important circumstance or second in importance in 16 out of 28 variables. Whether the child is male, belongs to an ethnic minority or lives with both parents are variables which are not as influential for most opportunities in the study.

A good monitoring system of opportunities for all may help the Chilean society strengthen consensus towards equity and provide policymakers the right incentives to design and implement better policies towards a more equitable society. From our perspective, a good monitoring system for this objective should have the following features: (i) Be comprehensive with respect the relevant dimensions deemed important for human development; (ii) Track the evolution of indicators in these relevant dimensions throughout the early stages of the life-cycle; (iii) Allow for monitoring of bundles of service delivery beyond individual services to characterize multiple deprivation; (iv) Allow a clear identification of a profile of inequality of opportunity to guide effective targeting, (v) Allow an assessment of the sources of growth in access to opportunities (neutral change, pro-vulnerable change, disequalizing change), (vi) Allow incentives to policymakers who go the extra-mile to include the more excluded groups, and (vii) Be easy to understand and with intuitive interpretations. The monitoring exercise presented in this report follows this guideline.

This report is organized in six sections as follows: Section 2 discusses key concepts related to the HOI. Section 3 presents the data sources and main empirical results in the five dimensions of basic opportunities considered. Section 4 presents the inequality of opportunity profile and the main sources of changes in the HOI. Section 5 discusses the multidimensional HOI. Section 6 concludes.

II.   HUMAN OPPORTUNITY INDEX

The Human Opportunity Index (HOI) is an equality of opportunity adjusted coverage rate. It is a measure that tracks advances towards basic opportunities for all with an emphasis on human capital accumulation in children and youth. A basic opportunity is a key service or minimum living condition that society wants everybody to have**.** The HOI is a coverage rate of basic opportunity net of inequality of opportunity. Inequality of opportunity is defined as a situation where access to basic opportunities is related to circumstances. Circumstances, as used here, are personal, family, or community characteristics over which an individual has no direct control. For ethical reasons, society wants these to be completely unrelated (directly or indirectly) to one's access to basic opportunities (Molinas et. al. 2012: 13). The HOI applies a penalty related to inequality of opportunity to adjust the coverage rate. The HOI is interpreted as the share of available opportunities that have been allocated in accordance to the principle of equality of opportunity.

The HOI is constructed based on specific coverage rates for different circumstance groups and the shares of these groups in the total population. Any systematic relationship of specific coverage rates and circumstances signal the presence of inequality of opportunity. If circumstances have no influence on opportunities, the specific coverage rates of the different circumstance groups will be similar to each other and to the overall coverage rate. Circumstance groups whose coverage rates are below the overall coverage rate are called vulnerable groups. Conversely, non-vulnerable circumstance groups are those whose specific coverage rates are either equal to or above the overall coverage rate.

To calculate the HOI, a penalty for inequality of opportunity is imposed on the average coverage rate. The penalty refers to access to a service that was allocated in violation of the equal opportunity principle (Figure 1). Every allocation of access to a service to circumstance groups above the overall average is a violation of the equality of opportunity principle, since access to the service is not independent of circumstances. In the figure, 10 percentage points of access to the service was allocated inequitably. The HOI is equal to the average coverage rate (59 percent) minus the penalty for inequality of opportunity (10 percentage points):   and therefore the HOI is 49 percent.

The penalty for inequality of opportunity is estimated by censoring the specific coverage rate of non-vulnerable groups to the overall coverage rate. In this sense, the HOI is a weighted average of the different circumstance groups censored at the overall mean.

The HOI can be represented as

$$HOI = \mu - P$$

where μ is the overall coverage of the society whereas P is the penalty associated with unequal access across circumstance groups.[1]

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[1] For a detailed mathematical derivation, see Appendix 1.

Figure 1: The Human Opportunity Index
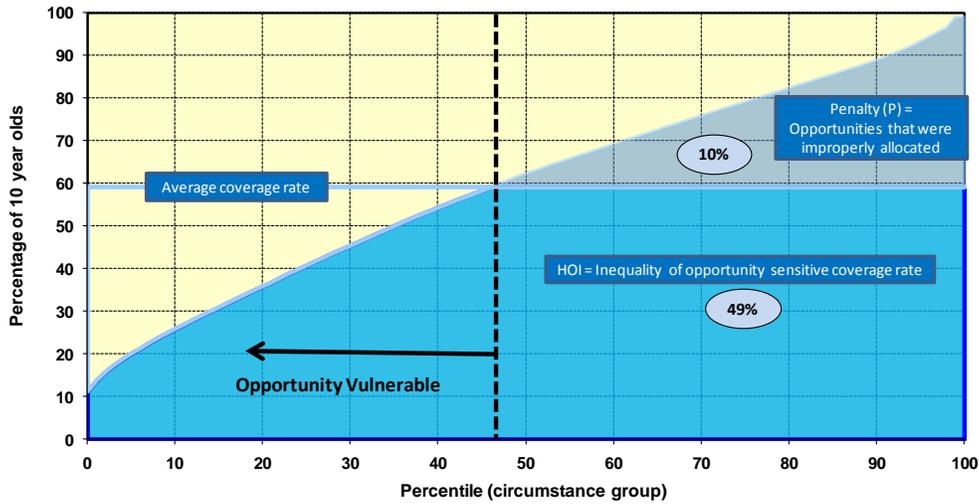
The HOI provides a way to measure progress toward universal coverage of basic opportunities as well as equitable access to those opportunities, in a single indicator. This is an improvement over other measurements of access to key services or minimum living conditions, such as a single aggregated coverage rate or incidence analysis. Unlike the coverage rate, the HOI is sensitive to how fairly coverage is allocated in a given society. Incidence analysis is also sensitive to the fairness of allocation, but unlike incidence analysis, the HOI is able to *capture* equitable access to a given service across many circumstance groups in a single number. The HOI helps to bring equity to the core of the policymaking process. It provides an operational measure that can easily be incorporated in program and project objectives and thus improvements can be tracked via standard public monitoring systems. A more complete discussion of the computation of the HOI is presented in **Box 2**.

An index of relative inequality of opportunity, the D-index, can be constructed from the coverage rate and the penalty for inequality of opportunity. The D-index is the ratio of the penalty for inequality of opportunity (P) and the coverage rate (μ). It is interpreted as the proportion of available opportunities that need to be re-allocated across circumstance groups to achieve equality of opportunity in a society.[2] The D-Index is a type of dissimilarity index often used in a variety of social sciences. Therefore the HOI can be written in terms of the D-index in the following manner: $HOI = \mu(1 - D)$.

The HOI runs from zero to 100. A society that has achieved universal coverage would score 100. A society that has universal deprivation would score 0. Universal coverage and deprivation are special cases where the HOI coincides with the coverage rate because personal circumstances are irrelevant; therefore, no penalty is imposed. In general, the HOI ranges from the squared coverage rate (in case of maximum penalty for inequality of opportunity) to the coverage rate (in case of no penalty).

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[2] The D-index ranges from zero to the proportion of the non-covered population (i.e. 1-μ)

The HOI satisfies several desirable properties. It is sensitive to both Pareto improvements and to scale transformations. That is, if coverage for one group increases without decreasing the coverage rates of the remaining groups, the HOI increases (Pareto consistent). Similarly, if coverage for all groups increases multiplicatively by a given scalar, the HOI also increases multiplicatively by the same factor (scale consistent). It is also sensitive to pro-vulnerable transformation. That is, if coverage rate of a vulnerable group increases holding the overall coverage rate constant, the HOI also increase. Similarly, for a given expansion of available services, the HOI increases more if the extra units of services are allocated to a vulnerable group.

Box 2: Empirically estimating the Human Opportunity Index

1. Estimate a separable logistic model on whether person i had access to a given basic good or service as a function of his or her circumstances. For completing a given grade on time, a series of indicator variables for age are used, besides the set of circumstances. In all cases, the functions are linear in the parameters. From the estimation of this logistic regression, obtain coefficient estimates.

2. Given these coefficient estimates, obtain for each person in the sample the predicted probability of access to the basic good or service in consideration, $\hat{p}_i$ based on the predicted relationship, $\hat{\beta}_k$,and a vector of their circumstances x_{ki} .

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

3. Compute the overall coverage rate μ,

$$\hat{\mu} = \sum_{1}^{n} w_i \hat{p}_i$$

   where $w_i = \dfrac{1}{n}$ or some sampling weights.

4. Compute the Dissimilarity Index D

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

5. Compute the penalty, $P = \mu * \hat{D}$

6. Compute the $HOI = \mu - P$

Source: Barros, Ferreira, Molinas and Saavedra (2009).

III.   THE HUMAN OPPORTUNITY INDEX THROUGHOUT THE LIFE-CYCLE IN CHILE: EMPIRICAL RESULTS

This section discusses the empirical findings of this analysis. The five broad dimensions discussed here are: (i) early childhood development, (ii) adequate learning, (iii) youth development, (iv) adequate housing and (v) basic opportunities for adults. These five dimensions encompass the biological, physical, psychological and social conditions needed to promote adequate human capital accumulation. For both early childhood and youth development we have indicators spanning both the cognitive and health oriented opportunities. For the dimension of adequate learning, we look at quality of education through two lenses --- first we look at timely completion rates and second we look at test scores for reading and math in the nationwide tests in the SIMCE. We use various opportunities to describe adequate housing which include basic services like adequate water and sanitation alongside indicators like access to computer and internet. We also include in our analysis opportunities pertaining to economic status as described by the opportunity of being out of poverty and or being part of the LAC region's middle class. As mentioned, these dimensions and indicators have been jointly selected with representatives of the Ministry of Social Development.

A. Data, Circumstances and Basic Opportunities

Four different datasets are suitably combined. These datasets are the *Encuesta Longitudinal de Primera Infancia*-ELPI, the *Encuesta Nacional de Juventud*-ENJ, the *Encuesta de Calidad de Vida de los Hogares*-CASEN, and test scores from the *Sistema de Medicion de Calidad de la Educacion*-SIMCE. Using these datasets we analyze basic opportunities from early childhood to adulthood. These four sources are relevant for two main reasons --- first, they allow us to describe basic opportunities that are needed for the development not only of young children but young adults as well. Secondly, the use of SIMCE and ELPI give us test scores that facilitate the understanding of the quality of education (SIMCE) and also early childhood development (Batelle, TEPSI and TVIP scores from ELPI).   Details of the data sources used are provided in Appendix 2.

The circumstance groups are constructed in the case of Chile from five exogenous circumstances. Since we are interested in the heterogeneity in access across groups based on circumstances, we focus on the differences in access across these groups, smoothing out the differences in access within the group. The five exogenous circumstances are gender, location, ethnicity of the child, parent's level of education and the family structure. Information on the five circumstances can be found in all four data sources. Since we have two possible values for gender (male, female), family structure (single parent household, both parents) and ethnicity (indigenous minority, non-indigenous minority); three values for location (rural, urban metropolitan region, urban non-metropolitan region) and four values for parents' education (less than primary, primary, secondary, more than secondary), we have a total of 96 possible circumstance groups. Each group has the same characteristics for these five variables.

As mentioned earlier, we have five broad dimensions - (i) early childhood development, (ii) adequate learning, (iii) youth development, (iv) adequate housing and (v) opportunities for adults. Below we look at Chile's performance in each of these dimensions separately. First we

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provide a brief summary of the findings in each dimension. This is followed a discussion of the emerging patterns.

B. Early Childhood Development

In the dimension of early childhood development we see that Chile does reasonably well with Human Opportunity Indexes (HOIs) above 70 in most of the indicators. All the indicators in this dimension use information from ELPI and pertain to children between ages 0 to 5.[3] As shown in **Table 2**, for health outcomes and cognitive outcomes Chile has high levels of the HOI and low levels of inequality of opportunity, as measured by the D-Index, except in the cases of access to adequate toys, pre-school attendance, and adequate vocabulary which show from moderate to high D-indices.

Table 2: HOI for Early Childhood Development Indicators (Year 2009)

	Early Childhood (0-5years)	Coverage	Penalty	HOI	D-Index
a.	*Cognitive*				
i.	*Inputs*				
1	*Parents involved with child*	72	2	70	3
2	*Adequate toys*	63	5	57	9
3	*Child attends pre-school*	70	3	67	5
ii.	*Outputs*				
1	*Adequate socio-emotional development*	79	3	75	4
2	*Adequate psychomotor development*	88	2	86	2
3	*Adequate vocabulary*	74	4	70	5
b.	*Health*				
i.	*Normal birth weight*	84	1	83	1
ii.	*Adequate height-for-age*	85	0	84	0

Source: Authors calculations based on ELPI 2009.

C. Education

In the education dimension, the picture which emerges is very different when looking at enrollment rates and adequate learning. There is a very high HOI (98) in school attendance but in adequate learning there is a low HOI and high inequality of opportunity. As **Table 3** indicates, for both completion rates on time and learning test scores Chile has HOIs less than 70. There is high inequality of opportunity in adequate learning. With the exception of school enrollment, the D-indexes range from a high value of 7 (adequate reading in grade 4) to 17 (math learning in grade 8).

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[3] See Table 1 in the introduction.

Table 3: HOI for Enrollment, Completion on Time, and Adequate Learning

2	Education	Coverage	Penalty	HOI	D-Index
a.	Attendance				
i.	Enrollment into school (7-16 age)	98	0	98	0
ii.	Completed grade 12 on time	40	6	34	15
b.	Learning				
i.	Adequate reading in grade 4	68	5	63	7
ii.	Adequate math in grade 4	65	6	59	9
iii.	Adequate reading in grade 8	64	5	59	8
iv.	Adequate math in grade 8	40	7	33	17

Source: Authors' calculation based on CASEN 2009 and SIMCE 2009.

D. Youth Development

Looking closely at some of the indicators reflecting youth development we see that Chile falls short of achieving satisfactory Human Opportunity Indexes. The achieved coverage levels are extremely unequally distributed among circumstance groups. In the sphere of cognitive development, a significant portion of Chilean youth (ages 15 to 19) does not read even once a week and are very reluctant to participate in the political process (see Table 4). When it comes to keeping adolescents away from drugs Chile performs well. However Chilean adolescents are less likely to play sports and there is high inequality of opportunity.

Table 4: HOI for Youth Development

3	Youth development	Coverage	Penalty	HOI	D-Index
a.	Cognitive Oriented				
i.	Read	46	3	43	7
ii.	Participate in political process	52	3	48	7
b.	Health Oriented				
i.	Play sports	53	6	48	11
ii.	Free from illegal consumption	92	2	91	2
iii.	Safe sexual practices	75	3	73	3

Source: Authors' calculation based on ENJ 2009.

E. Housing

In the dimension of housing we have five basic opportunities along which Chile has a varied performance ranging from HOIs of 90 or more in adequate water and sanitation to HOIs of less than 50 in computer and internet (Table 5)**.** For adequate water and sanitation Chile has almost full coverage and the D-index is also small. However the performance is

progressively worse as we move from adequate housing material (floor, walls, and ceilings) to access to computer and internet. Access to computers and internet shows very high inequality of opportunity with a D-index of 18 for computers and 28 for internet.

Table 5: HOI for Housing

4	Housing	Coverage	Penalty	HOI	D-Index
a.	Adequate water	97	2	95	2
b.	Adequate sanitation	93	4	90	4
c.	Adequate housing material	79	4	74	6
d.	Computer	50	9	41	18
e.	Internet	31	9	22	28

Source: Authors' calculation based on CASEN 2009.

F. Basic Opportunities for Adults

Though Chile has moved most of its population out of poverty there is still a long way to go to achieve similar success in the provision of access to tertiary education and the opportunity to move into the LAC middle class (Table 6)**.** The fifth dimension of adult opportunities looks at the access to tertiary education, out of poverty condition and inclusion in the LAC middle class. We have used two measures of poverty, the international extreme poverty line at per-capita $1.25 a day and the LAC poverty line of $4.00 a day per capita. With both these measures, Chile has succeeded in achieving a high HOI (around 90) for being out of poverty. However as regards movement into the LAC middle class as defined by a per-capita income of $10.00 a day, the HOI is only 51 with a high D-index. [4]

In access to higher education, which may capture the future earning potential of the population, there is a low HOI. In this opportunity there is high inequality of opportunity (D-index of 29) alongside the observed low HOI of 34.

Table 6: HOI for Adults

5	Adults	Coverage	Penalty	HOI	D-Index
a.	Access to some superior education	34	10	24	29
b.	No poverty (1.25 U$S/day)	98	0	97	0
c.	No poverty (4 U$S/day)	90	2	88	3
d.	Access to the LAC Middle Class (10 U$S/day)	51	7	43	15

Source: Authors' calculation based on CASEN 2009.

G. Emerging Patterns

Looking at each of the five dimensions considered, the broad pattern that emerges is that Chile does well in providing equitable access to fundamental basic opportunities. However, Chile's performance leaves significant scope for improvement in several other indicators

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[4] This cutoff is the one recommended in Lopez-Calva and Rigolini (2011).

which are perhaps more related to quality. Next we look at Chile's performance in some of these dimensions more closely. **Figure 2** shows the HOI patterns while **Figure 3** shows the patterns of the D-index.

Figure 2: Comparison of HOI across Dimensions
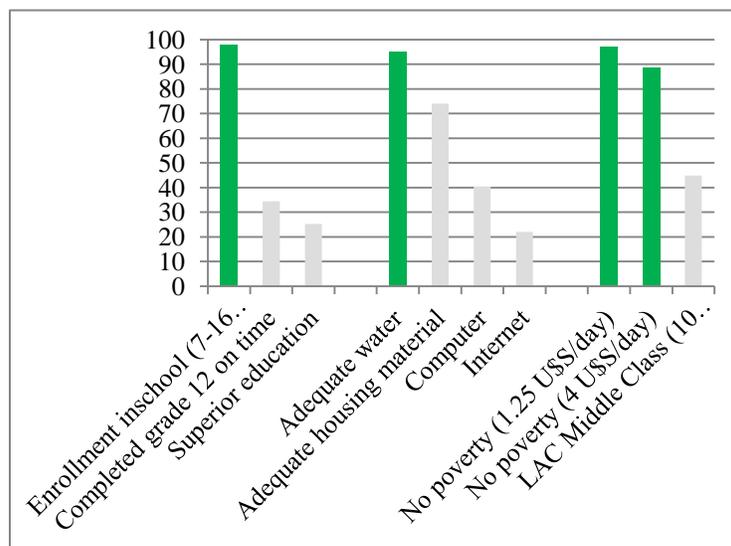
Source: Authors' calculations based on CASEN 2009.

In the dimension of education, Chile has achieved almost universal enrollment but for the more advanced indicators performance is unsatisfactory. In Chile the HOI for finishing grade 12 on time is only 40 and the D-index is 15. Furthermore when considering access to tertiary education the situation is even worse with an HOI of 34 and a D-index of almost 29. These findings clearly suggest that circumstances matter increasingly for higher levels of education.

Figure 3: The D-index for Opportunities across dimensions.
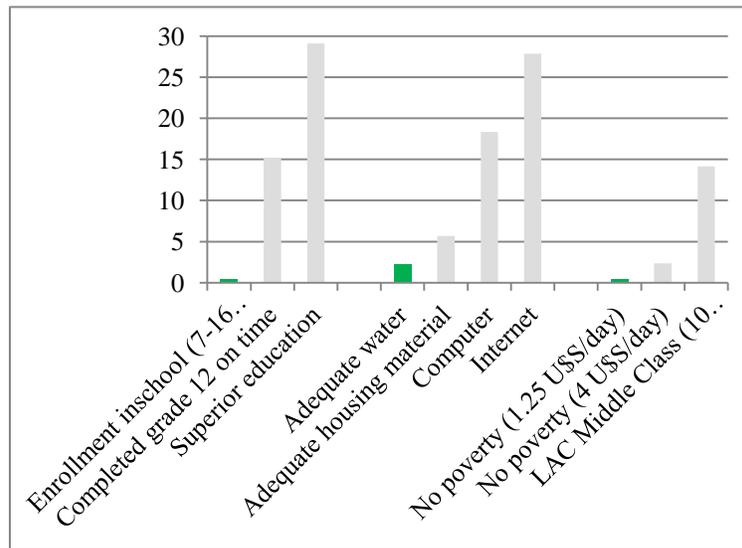
Source: Based on authors' calculation from CASEN 2009.

In the dimension of housing, the observed pattern is to a large extent similar to the one observed in education. Chile has a high HOI for access to water and sanitation. However, HOIs are low for more advanced facilities such as access to computer and internet. Moreover, there is high inequality of opportunity to access these facilities. This is concerning, since it may reflect low prospects of upward positional mobility for vulnerable groups. The idea behind upward positional mobility for vulnerable groups is that individuals from disadvantaged circumstances are able to earn higher incomes at a faster rate than high income people in a society. For this to happen, all individuals should be able to build up the human capital necessary to have higher income in the future. If the opportunities needed for the formation of basic human capital are not available to different circumstance groups, then the individuals with access would largely come from more advantaged groups and the harsh conditions of disadvantaged groups will persist over time.

In the case of adulthood opportunities the pattern is also similar. In the matter of keeping individuals out of poverty, Chile has done very well, with a very high HOI for being outside of extreme poverty (98). However for the second tier indicator of moving the Chilean population into the LAC middle class, the HOI is low (51), with high inequality in access across groups (D-index of 15).

The findings so far suggest the following. Chile has achieved high levels of HOIs and equality in access across circumstance groups for basic services. However for the more advanced opportunities Chile's performance is not optimal as yet, with low HOIs and high levels of inequality of opportunity.

IV. MOST SALIENT CIRCUMSTANCES AND SOURCES OF HOI CHANGES: DECOMPOSITION EXERCISES

In this section we present two types of decompositions. The first one aims at parsing out the contribution of different circumstances to inequality of opportunity at a given point in time. The second one aims at better understanding the sources of changes in the HOI over time.

A. Sources of Inequality of Opportunity

For any given opportunity, not all the circumstances are necessarily equally important in contributing to the inequality of opportunity. The inequality of opportunity profile provides the contribution of each of the circumstances to the overall observed inequality Understanding the inequality profile is central to a targeted approach towards expanding the HOI.

To unravel the sources of inequality at a given level of the D-index we use the Barros decomposition method. The methodology (discussed in detail in Appendix 1) decomposes the contribution of each circumstance to the overall observed inequality of opportunity. The sum of the contributions by each circumstance adds to 100 percent of the observed inequality of opportunity. The idea is to find the amount of inequality of opportunity due to variations within a given circumstance holding fixed all the other circumstances at their average levels. The main challenge for this exercise is the inherited non-linearity of the model. That is, depending on which circumstance is allowed to vary and which others at held at their average levels, the results can change. The proposed decomposition relies on finding all possible permutations (of the one allowed to vary while keeping the other fixed at their mean) among the set of circumstances. The contribution of a given circumstance to the overall level of inequality of opportunity, D, is given by the average of the measures obtained in the all possible permutations.

Using the Barros methodology we find that for most of the basic opportunities studied here, parent's educational background is the most salient circumstance among the five circumstances considered. The circumstances considered include gender, presence of both parents, ethnicity, parental education, and location. For 24 of the 28 opportunities studied we find that parent's educational background is the most salient source of inequality of opportunity. The four basic opportunities where this is not the case are in youth development (*play sports* and *free from illegal consumption*, where gender is the most important) and in housing (*adequate sanitation* and *water*- where location is the most important driver of inequality (see Table 7 for a detailed table of all results). In three out of these four basic opportunities, parental education is the second most important circumstance considered. Specifically, with the sole exception of *free from illegal consumption*, parental education is either the most important circumstance or second in importance. This variable seems to be promising for targeting purposes, in order to expand the provision of basic opportunities more equitably.

Next to parental education, location seems to be the second most important circumstance. It is the most important circumstance in the provision of adequate water and sanitation. It is the second most important circumstance in explaining exclusion in 14 other basic opportunities, including pre-school attendance, access to adequate toys, adequate socio-emotional development, adequate vocabulary, completion of 12th grade on time, frequent reading when young, participation in the political process, free from illegal consumption, adequate housing material,

access to computer and internet, access to some tertiary education, freedom from extreme poverty (international measure), and access to the LAC middle class. That is, location is either the most important circumstance or second in importance in 16 out of 28 variables. This implies that incorporating a regional focus in the design, monitor and evaluation of public policies may have substantial payoffs in improving equity. Figure 4 provides a graphical description of some of the opportunities. Appendix 3 presents a sub-national analysis of the HOI in the five dimensions considered.

Table 7: Inequality of Opportunities Profile

Circumstances that contributes to inequality of opportunity (%)

Opportunities	Gender	Both Parents	Ethnic	Parents education	Location
1 Early Childhood (0-5years)					
a. Cognitive					
i. Inputs					
1 Parents involved with child	16	3	9	65	7
2 Adequate toys	1	4	6	67	22
3 Child attends pre-school	2	19	2	37	41
ii. outputs					
1 Adequate socio-emotional development	5	5	0	73	17
2 Adequate psychomotor development	38	0	9	44	9
3 Adequate vocabulary	3	1	10	76	10
b. Health					
i. Normal birth weight	34	10	3	53	1
ii. Adequate height-for-age	7	37	6	38	12
2 Educational Performance					
a. Completion on time					
i. Enrollment rates (ages 7-16 years)	0	14	2	75	9
ii. Completed grade 12 on time	2	1	0	93	3
b. Learning					
i. Adequate reading in grade 4	22	6	1	69	2
ii. Adequate math in grade 4	1	10	5	80	4
iii. Adequate reading in grade 8	22	6	2	70	0
iv. Adequate math in grade 8	8	8	3	74	6
3 Youth development					
a. Cognitive					
i. Read	19	0	10	40	31
ii. Participate in political process	10	9	1	62	18
b. Health					
i. Play sports	77	1	1	17	5
ii. Free from illegal consumption	43	23	3	4	28
iii. Safe sexual practices	5	30	7	55	3
4 Housing					
i. Adequate water	0	0	9	18	73
ii. Adequate sanitation	0	0	9	30	61
iii. Adequate housing material	0	5	3	67	24
iv. Computer	0	9	3	72	15
v. Internet	0	11	3	69	16
5 Adults					
i. Superior education	5	3	3	67	22
ii. No poverty ($1.25 per day)	4	1	29	49	17
iii. No poverty ($4 per day)	12	4	6	62	16
iv. Middle Class ($10 per day)	11	3	2	67	17

Source: Based on author's calculation from CASEN, ELPI, ENJ and SIMCE.

Whether the child is male, belongs to an ethnic minority or lives with both parents are variables which are not very salient for most opportunities studied here. Gender is the most important circumstance in the youth development basic opportunities of playing sports and being

free from illegal consumption. It is the second most important in five others: *parents involved with child, adequate psychomotor development, normal weight at birth,* and *adequate math for grades 4* and *8*. Presence of both parents is the second most important circumstance in five out 28 basic opportunities considered: *school enrollment, adequate reading in grades 4* and *8, free from illegal consumption*, and *safe sexual practices*. Ethnicity is the second most important circumstance in only one out 28 basic opportunities considered: *no poverty (4 US$/day)*. See Table 7 for more details.

Figure 4: Decomposition of the HOI by Circumstance
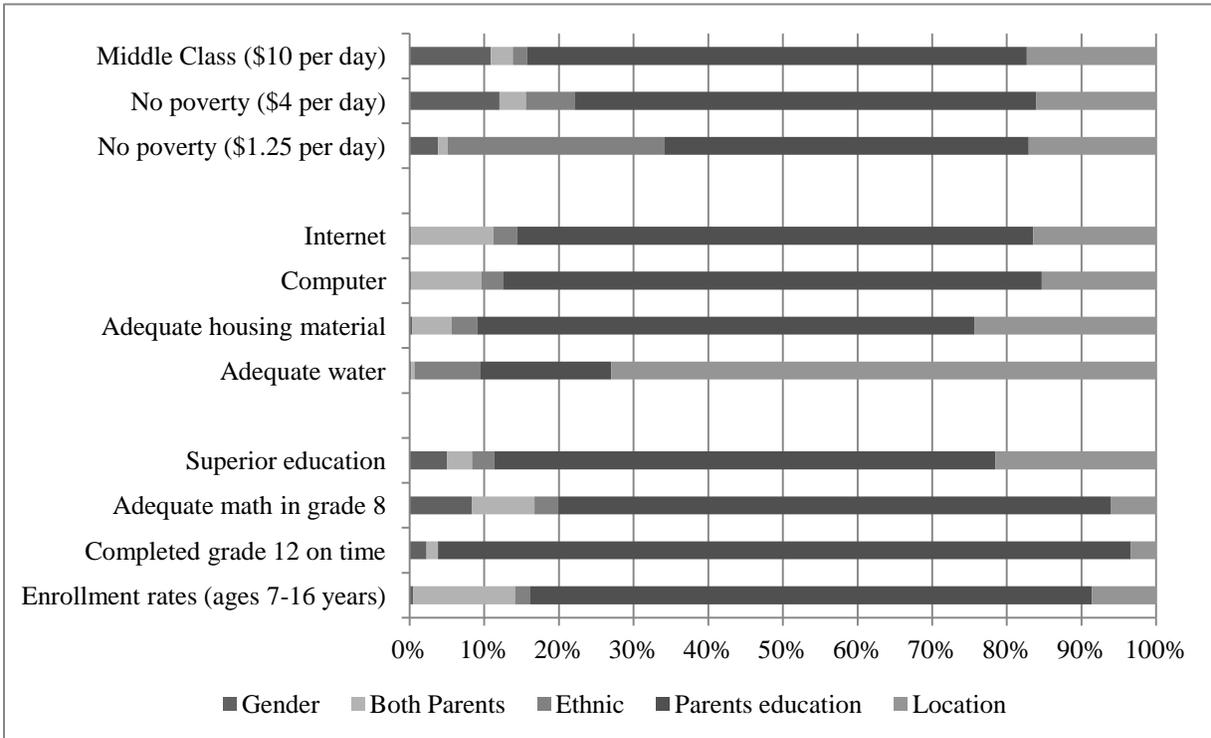
Source: Based on author's calculation from CASEN, ELPI, ENJ and SIMCE.

B. Sources of Changes in the HOI over time for selected opportunities

Though we are not able to follow all of the opportunities over time, we can do so for the opportunities from CASEN. In the education dimension, we have the HOIs for school attendance and completion of grade 12 on time for the 1996-2009 period. In the housing dimension, we have the HOI for access to water, sanitation, and adequate housing materials for the same period.

We see a general trend of an increase in the HOI for all the opportunities studied. However the reasons for these changes could be different. Below we describe the framework to decompose the various possible channels of changes to the HOI.

The drivers of change can be useful in helping policymakers understand the effect of past policies and design new ones to best improve equality of opportunity for all Chileans. The HOI is determined fundamentally by the share of circumstance groups within the total population, and of the coverage rate of basic opportunities enjoyed by each specific circumstance group. Hence, the HOI can only change when at least one of these two features changes. Any change in the index can be traced either to changes in the distribution of circumstances (*composition effect*) or to changes in group-specific coverage rates (*coverage effect*), see Molinas et. al 2010. The coverage effect can be further decomposed into changes due to changes in equality of opportunity (*equalization effect*) and changes due to average coverage rates (*scale effect*) (Table 5). Below we discuss the intuition behind each effect and the related policy implications. For the mathematical description see Box 3.

Figure 5: Sources of Change of the HOI
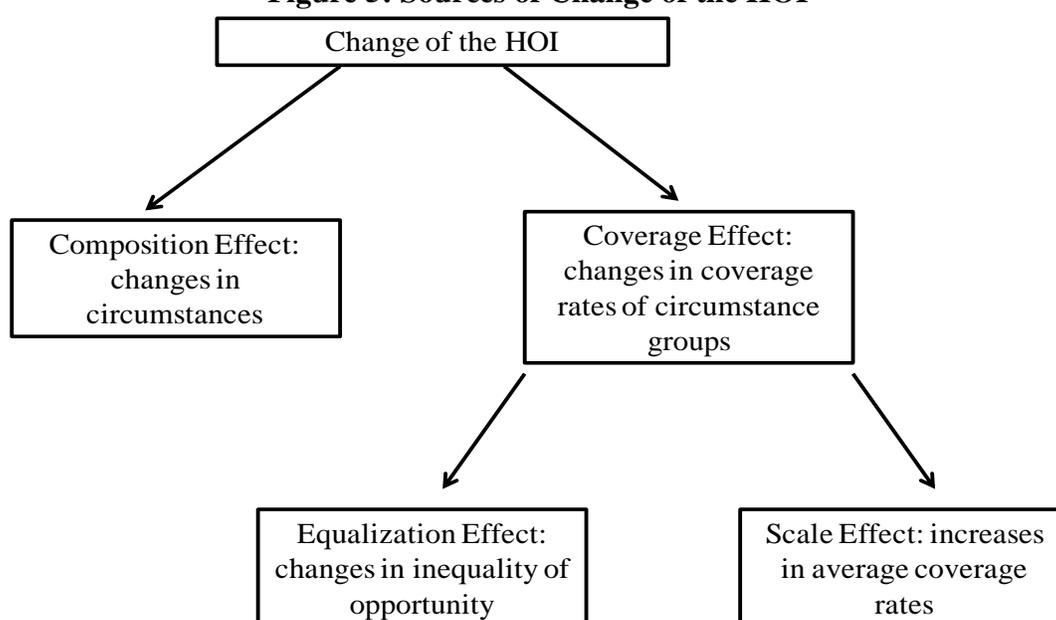
Source: Molinas, Barros, Saavedra, and Giugale (2012).

The composition effect mainly reflects structural demographic changes, overall economic development and increased past investments in education. Examples include families moving from rural to urban areas or the gradual increase over time of parental education. The causes of such shifts in circumstance group populations are not generally tied directly to current policies in specific sectors, but can be driven by broader macroeconomic policies, cross-sector and past sector policies (for example, increasing education provision in previous generations).

The coverage effect can arise in two distinct ways, which shed light on the effect of current policies. One way is to simply increase the average coverage rate for a given basic service proportionately for all circumstance groups, with no reference to equity. In this case, the degree of equality of opportunity would remain unchanged and the HOI would increase exclusively due to a change in the total coverage rate. We call this type of change a *scale effect*. On the other hand, progress theoretically could be achieved by increasing coverage rates among vulnerable groups, compensated by a concomitant decrease in coverage rates among non-vulnerable groups that would hold the overall coverage rate unchanged. In this case, since the overall coverage rate

remains unchanged, the HOI increases only due to the decline in the degree of inequality of opportunity. We call this type of change an *equalization effect*. In principle, the coverage effect can always be further decomposed into a scale and an equalization effect.

Box 3: Mathematical Decomposition of Sources of Change of the HOI

Mathematically a change in the HOI between two periods can be written as a sum of the three effects, Composition, Scale and Equalization effects. We have the HOI for two periods, HOI_1 and HOI_2. Therefore the change in HOI is:

$$\Delta\ HOI_2 - HOI_1$$

$$= \mu_2(1 - D_2) - \mu_1(1 - D_1)$$

$$= [\mu_2(1 - D_2) - \mu_2(1 - D_{mix})] + [\mu_2(1 - D_{mix}) - \mu_{mix}(1 - D_{mix})] + [\mu_{mix}(1 - D_{mix}) - \mu_1(1 - D_1)]$$

Equalization effect	Scale effect	Composition effect

where μ , D_m, refers to the overall coverage and the D-Index, and $\mu_{mix}D_{mix}$ are calculated using the probabilities of access of period 2 for each circumstance group, but the weight attached to that group comes from period 1. Therefore we are using the distribution of access to the opportunity from period 2 and the distribution of population is held fixed at that of period 1.

Source: Molinas, Barros, Saavedra, and Giugale (2012).

The relative weights of the scale and equalization effects indicate whether sectoral policies have simply expanded average coverage on a distribution-neutral basis across vulnerable and non-vulnerable groups, or whether they have focused more specifically on improving equity by promoting a larger expansion of coverage among the vulnerable groups. The expansion of basic opportunities in a country can be more or less equitable. The extreme case of actually taking away opportunities from advantaged groups and giving them to disadvantaged groups—a pure equalization effect—does not often occur in the real world. Instead, as service access expands, additional "units" of a service can be allocated disproportionately to a disadvantaged group (a positive equalization effect), disproportionately to groups already advantaged (a negative equalization effect), or proportionately for all (no equalization effect and a positive scale effect). The scale effect can be negative as well, if the coverage of a service declines.

Table 8: Sources of Change for HOI

	HOI 1996	HOI 2009	Equalization effect (%)	Scale effect (%)	Composition effect (%)
Enrollment (7-16 age)	95	98	22	35	43
Completed grade 12 on time	19	34	19	93	-12
Adequate water	83	95	28	36	35
Adequate sanitation	68	90	21	37	42
Adequate housing material	39	74	27	49	24

Sources: based on Authors' calculation using CASEN data.

For Chile we see that the HOIs have improved for all the five basic opportunities considered. Below we discuss the contribution of the composition and coverage (scale and equalization) effects. Among the five HOIs considered, the contribution of the equalization effect is on average 23 percent whereas the contribution of the scale effect is 50 percent and the contribution of the composition effect is 26 percent.

In case of each of the five opportunities the coverage effect is the more prominent one, and it explains more than 50 percent of the overall change. Therefore we can say that the majorityof the improvements in the HOI can be attributed to the sectoral policies of the Chilean government during the period considered.

The contribution of the equalization effect is also significant though not dominant across the five opportunities. The contribution of the equalization effect to the overall change in HOI between 1996 and 2009 ranges from 19 percent in the case of completion of grade 12 on time to 28 percent in the case of adequate water. Thus, there is still room for policy to improve access to the most vulnerable groups by an improved and targeted approach to providing basic opportunities.

Within the coverage effect, the scale effect is more prominent than the equalization effect. This implies that the increase in the HOIs is mainly due an expansion of coverage proportionally across all circumstance groups. The contribution of the scale effect to the changes in the HOI ranges from 35 percent in school enrollment to 93 percent in completion of 12th grade on time.

Changes in the distribution of circumstances (composition effect) played a significant role, although not a dominant one, in the changes of all five HOIs. The contribution of composition effect ranges from -12 to 43 percent. The contribution of the composition effect is negative (-12 percent) when decomposing the observed change in completion of grade 12 on

time. This situation may indicate that the share of vulnerable groups have increased for this indicator during the 1996 to 2009 period. This observed situation may have occurred when more students from vulnerable families are retained by the education system in 2009 as compared to 1996. That is, *ceteris paribus* changes in the distribution of circumstances during 1996-2009 would have produced a reduction of the HOI of 1.8 percentage points, equivalent to a reduction of 9 percent from the 1996 HOI. The contribution of the composition effect in the expansion of adequate sanitation has been quite noticeable. It contributed to 42 percent of the observed change of 22 percentage points in the HOI during the 1996-2009. That is, *ceteris paribus* the composition effect in that period contributed to the HOI expansion in adequate sanitation by 9.2 percentage points, equivalent to an increase of 14 percent from the 1996 HOI for this indicator.**(Table 8)**

V. MULTIDIMENSIONALITY

Another way to capture progress towards equal opportunity with more advanced indicators is to focus on bundles of basic opportunities rather than looking at each basic opportunity individually. If there is less than universal coverage a question which may arise is if the individuals who still lack access are different for different opportunities or are the same individuals lacking a large number of the opportunities. The second scenario implies that deprivation is deeper than the first.

Whether individuals who lack access are different for different opportunities or are the same individuals lacking a large number of the opportunities may have very different policy implications for targeting. Targeting for the first scenario requires having a different roster for different opportunities. However, a single roster for several basic opportunities may be more efficient when the same individuals are lacking a large number of the basic opportunities.

To be able to capture this inherent multidimensionality in the HOI framework we explore the idea of having HOIs for an entire bundle of services together, rather than individual HOI indicators. Usually the demands on a survey for any form of multidimensional analysis are high, in the sense that information on all the indicators of interest should be contained in the same survey, greatly restricting the kind of bundles we can look at.

The bundles of basic opportunities constructed here in the spirit of multidimensional analysis draw indicators from all 4 surveys. First we restrict ourselves on bundles of basic opportunities coming from the same survey. Second, we explore to what extent the product of the probabilities of access to each of the component basic opportunities provides good approximation to the true multidimensional indicator.

Here we show the multidimensional HOI for four bundles which span the lifecycle of a "representative individual" from childhood through adulthood. The dimensions we look at are (i) early childhood development, (ii) Adequate learning, (iii) Adequate youth development, and (iv) Adequate core housing.

The multidimensional indicator for early childhood development looks at the joint probability of access for three indicators. These indicators are: adequate socio-emotional development, adequate psychomotor development and adequate vocabulary. The definition of these indicators is the same as presented above when discussing the individual ones. The multidimensional indicator requires individuals to have access to all three single indicators. The information for these three indicators come the ELPI survey.

The multidimensional indicator of adequate learning looks at the joint achievement of adequate reading and math in grade 8. The indicators are defined similarly as the single indicators discussed above. The information comes from SIMCE 2009.

The multidimensional indicator for youth development looks at the joint achievement of participation in political process, free from illegal consumption and safe sexual practices. The indicators are similarly defined as discussed above for the single indicators. Data comes from ENJ 2009.

The multidimensional indicator for core housing looks at the joint access to adequate water, adequate sanitation and adequate housing material. The data comes from CASEN 2009 and the comprising indicators are defined as discussed above.

Table 9 presents the results for the four multidimensional HOIs. The multidimensional HOI for early childhood development is only 35. This low multidimensional HOI contrasts with the single HOI for each of the three comprising indicator. The single HOIs range from 74 (Adequate vocabulary) to 88 (adequate psychomotor development). Similarly, the inequality of opportunity index (D-index) is 12 for the multidimensional indicator, implying that 12 percent of available opportunities need to be re-allocated across circumstance groups to achieved equality of opportunity. The D-indexes of the single indicators have are 5 and 4 respectively.

Table 9: HOI for Multidimensional Indicators

Multidimensional Indicators	Coverage	Penalty	Multidimensional HOI	D-Index
Early Childhood Development	35	4	31	11
Adequate Learning	36	6	29	18
Youth Development	11	1	10	8
Core Housing	75	6	69	8

Source: Authors' calculation based on ELPI 2009, SIMCE 2009, ENJ 2009, and CASEN 2009.

The multidimensional HOI for adequate learning is 29. This low multidimensional HOI is consistent with the low single HOI for adequate math in grade 8 of 36. Similarly, the D-index is 18 for the multidimensional indicator, close to the D-index of 17 for adequate math in grade 8.

For youth development, the multidimensional HOI is only 10. This very low multidimensional HOI contrasts with the single HOI for each of the three individual indicators. These HOIs range from 52 (participation in the political process) to 92 (free from illegal consumption). The D-index is 8 for the multidimensional indicator, which is similar to the D-index for participation in the political process.

For core housing, the multidimensional HOI is 69. This multidimensional HOI is lower than each of the three individual indicators. These single HOIs range from 79 (adequate housing material) to 97 (adequate water). The inequality of opportunity index (D-index) is 8 for the multidimensional indicator. The D-indexes of the single indicators range only from 2 to 6.

The general trend that emerges is that the multidimensional HOI is usually much lower than any of the single indicator HOIs. The difference between relatively high single HOIs and low multidimensional HOI may be pointing out to the fact that deprivation of basic opportunities in Chile may be relatively spread out.[5]

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[5] In Appendix 4, we explore to what extent the product of the probabilities of access to each of the component basic opportunities provides a good approximation to the true multidimensional indicator.

VI. CONCLUSION

Chile's progress in reducing poverty and expanding basic opportunities for its citizens has been impressive. As documented in Molinas et al. (2012), Chile leads the HOI for school enrollment, access to electricity, water and sanitation among 18 Latin American countries in (circa) 2010. Challenges remain in ensuring equal access for more advanced opportunities across all social (circumstance) groups. Opportunities in the areas of quality of education (test scores for grade 4 and 8), access to higher education, active youth participation in the political process and access to computers and internet constitute challenging areas for Chile's current social policy.

Overcoming the bottlenecks for expanding these opportunities is crucial for advancement towards the ideal of opportunities for all so that all citizens may lead the life of their choosing. Social mobility of vulnerable groups necessitates that all individuals build up their human capital through access to both basic and more advance opportunities that enable them to have a fair chance to move upwards in society based on their effort and choices. If there is inequality of opportunity in dimensions important for building human capital then the individuals with access would largely come from more advantaged groups and the harsh conditions of disadvantaged groups will persist over time.

A monitoring system of basic opportunities that effectively incorporates equity concerns may help policymakers to design better policies to foster social upward mobility among the vulnerable groups in Chile. A good monitoring system for mainstreaming equity in tracking the opportunities for social mobility should have the following features: (i) Be comprehensive with respect the relevant dimensions deemed important for human development; (ii) Track the evolution of indicators in these relevant dimensions throughout the early stages of the life-cycle; (iii) Allow for monitoring of bundles of service delivery beyond individual services to characterize multiple deprivation; (iv) Allow a clear identification of a profile of inequality of opportunity to guide effective targeting, (v) Allow an assessment of the sources of growth in access to opportunities (neutral change, pro-vulnerable change, disequalizing change), (vi) Allow incentives to policymakers who go the extra-mile to include the more excluded groups, and (vii) Be easy to understand and with intuitive interpretations.

The monitoring exercise of opportunity for social mobility based on the Human Opportunity Index (HOI), an equality of opportunity adjusted coverage rate, complies with all seven attributes described above. This report introduces equity concerns with the HOI across 28 basic opportunities covering relevant biological, physical, psychological, and social dimensions. The analysis covers the periods from early childhood to adulthood. The HOI has a set of desirable properties beyond its simplicity, intuitiveness, and tractability. It is Pareto consistent because if coverage for one group increases without decreasing the coverage rates of the remaining groups, the HOI increases. It is scale consistent, if coverage for all groups increases multiplicatively by a given scalar, the HOI also increases multiplicatively by the same factor. It is *pro-vulnerable* because if the coverage rate of a vulnerable group increases holding the overall coverage rate constant, the HOI also increases. For a given expansion of available services, the HOI increase more if the extra units of service are allocated to the more vulnerable. By using this measure the performance of those policymakers that include otherwise excluded groups would look better, creating an incentive to them for proper targeting. The HOI provides a

tractable way, in a single indicator, to measure progress toward universal coverage of opportunities as well as equitable access to those opportunities.

The HOI indicators used in this report fall under the following five categories: (i) early childhood development, (ii) adequate learning, (iii) youth development, (iv) adequate housing and (v) basic opportunities for adults. The dimensions and indicators have been selected jointly with representatives of the Chilean Ministry of Social Development (former MIDEPLAN). Most of the indicators broadly correspond to the various schemes (such as the Chile Crece Contigo and Chile Solidario) which operate under the coordination of the Ministry of Social Development. Four different datasets are used in this monitoring exercise. These datasets are the Encuesta Longitudinal de Primera Infancia-ELPI, the Encuesta Nacional de Juventud-ENJ, the Encuesta de Calidad de Vida de los Hogares-CASEN, and test scores from the Sistema de Medicion de Calidad de la Educacion-SIMCE.

In this report the five characteristics along the lines of which we study inequality of opportunity are gender, location, ethnicity of the child, parent's level of education and the family structure. We refer to these five characteristics as circumstances and the population can be divided into groups based on these which we refer to as circumstance groups.

The broad pattern that emerges is that Chile does well in providing equitable access to fundamental opportunities but not in several other advanced indicators. In the dimension of education Chile has achieved almost universal enrollment but for the more advanced indicators such as learning in grade 4 and 8, finishing grade 12 on time, and access to tertiary education Chile's performance is unsatisfactory. In the dimension of housing, there are high HOIs for access to water and sanitation but low for access to computers and the internet. In the case of adulthood opportunities, the country has done very well in keeping individuals out of poverty, but in moving the Chilean population into the LAC middle class, the HOI is low (51), with high inequality in access across groups (D-index of 15).

For a limited set of basic opportunities where dynamic analysis could be undertaken, we observe that the leading source of change in the HOI over time is neutral change across circumstance groups as captured by the scale effect. The contribution of the scale effect is on average 50 percent of the total observed change. The contribution of pro-vulnerable change as captured by the equalization effect is on average 23 percent of total change whereas the contribution of changes in the distribution of circumstances as captured by the composition effect is 26 percent of total change.

The contribution of pro-vulnerable change to the expansion of basic opportunities can be increased by targeting allocations towards groups are more vulnerable rather than a neutral distributive change, which appears to have been implemented until now. To achieve such an objective policymakers need to effectively utilize two pieces of information: (i) the profile of the excluded and (ii) the depth of the exclusion, both of which can be provided by an HOI analysis

Exclusion (inequality of opportunity) in Chile operates mainly on the basis of parental education and location. Parents' educational background is the most important circumstance among the five circumstances considered here for 24 of the 28 basic opportunities studied. Location is the second most important circumstance. The other three circumstances, namely,

whether the child is male, belongs to an ethnic minority or lives with both parents are not very important for most opportunities studied here.

The depth of exclusion can be assessed by analyzing whether the same individuals lack access to a large number of the opportunities or whether the lack in access is more spread out across the population. Deprivation is deeper in the former than in the latter. The depth may have very different policy implications for targeting. Targeting when individuals who lack access are different for different basic opportunities requires a specific roster for each opportunity. However, a single roster for several basic opportunities may be more efficient when the same individuals lack access to a large number of the basic opportunities.

To capture the depth of exclusion in the HOI framework we explore the concept of multidimensionality and calculate HOIs for a bundle of services, as a complement to the calculation of individual HOIs for each indicator. The multidimensional HOI for early childhood development is only 31. This low multidimensional HOI contrasts with the single HOIs for each of the three comprising indicator that range from 63 (Adequate toys) to 88 (adequate psychomotor development). The multidimensional HOI for adequate learning is also low at 29, though in this case it is consistent with the low single HOI for adequate math in grade 8 of 33. For youth development, the multidimensional HOI is only 10, contrasting with the single HOI for each of the three comprising indicator that range from 52 (participation in the political process) to 92 (free from illegal consumption). Finally, for core housing, the multidimensional HOI is 69, which is lower than each of the three comprising indicator that range from 79 (adequate housing material) to 97 (adequate water). The difference between relatively high single HOIs and low multidimensional HOI points to the fact the overlap in access to services is low for Chile. If the same individuals had access to all the opportunities then the observed pattern would show single indicator HOIs and multidimensional HOI being very similar since it is the same people we find as having access. However if it were the case that different groups of people had access to different services, then when we use the multidimensional HOI to capture joint access to all the services in the bundle together, we will naturally see fewer individuals with access to the bundle. In this spirit the observed diverge between the single HOIs and the lower multidimensional HOI implies that deprivation in access to opportunities is relatively spread out in Chile.

This monitoring exercise can be further developed in several directions. One direction is to explore the connection between mobility across circumstance groups in access to basic opportunities early in the life-cycle and later social mobility as adults across these groups in the economic dimensions. There may be some early signals of either acceleration or stagnation of the prospects for social mobility for adults that may be captured at earlier stages by studying access to basic opportunities for children. This would allow policymakers to make more timely interventions to foster upward social mobility. Another direction of future work is to explore the connection between basic opportunity for all in accumulating basic human capital in childhood and the equality of opportunity in the labor market later in life. By differentiating and better understanding the sources of inequality of opportunity that occurs *prior to* entry in the labor market and *in* the labor market, policymakers may have more accurate tools to diagnose current problems and to act upon them.

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VIII.   APPENDICES

Appendix 1: A. Mathematical derivations: The Human Opportunity Index

The HOI can be expressed in terms of the probability of access as a function of circumstance. Let the characteristics along which we do not wish to have exclusion/inclusion are given by X and the circumstance group specific coverage rates be given by $p(x)$ which depends on the set of circumstances. Let the population distribution of individual's across X be given by $F_X(x)$. Therefore the overall coverage, penalty and the HOI can be written in the following manner:

$$\mu = \int p(x) d\, F_X(x)$$

$$P = \int\limits_{p(x)>\mu} (p(x) - \mu) dF_X(x)$$

$$HOI = \int Min(p(x), \mu) dF_X(x)$$

The HOI can be also expressed as a function of the dissimilarity index (D-Index). The D-index is the ratio of the penalty for inequality of opportunity and the coverage rate. It is interpreted as the proportion of available opportunities that needs to be re-allocated across circumstance groups in a society to achieve equality of opportunity. Mathematically it is,

$$D = \int_{p(x)>\mu} \frac{(p(x)-\mu)}{\mu} dF_X(x) \ .$$

Therefore the HOI can be written in terms of the D-index in the following manner:

$$HOI = \mu(1 - D).$$

Barros Value decomposition of the HOI[6]

Ideally, one would like to express the dissimilarity index D, as

$$D = \sum_{k=1}^{m} C_k$$

where C_k denotes the dissimilarity in opportunity due to differences in circumstance k.

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[6] This decomposition was proposed for Ricardo Paes de Barros for this report.

Although this decomposition could be obtained in several alternative forms, none of them ends up being very simple and intuitive due to the inherited non-linearity of the model. One possibility for such decomposition is described in the sequence.

Let *M* denote the set of all *m!* possible permutations of the *m* circumstances one is considering. Let *j* denote one such permutation (i.e., a sequence of circumstances in a given order) and *j(l)* the *l*th circumstance in this sequence. Let

$$C_{j,l} = \sum_{k=j(l)}^{j(m)} f_k(X_{ki})$$

Note that for all sequence (permutation) *j*

$$\sum_{k=1}^{m} f_k(X_{ki}) = C_{j,1} = \sum_{k=j(1)}^{j(m)} f_k(X_{ki})$$

and that

$$\sum_{k=1}^{m} f_k(X_{ki}) = \left(\sum_{k=j(1)}^{j(l-1)} f_k(X_{ki}) \right) + C_{j,l}$$

Hence, $C_{j,l}$ properly isolates the inequality in opportunity due to the circumstances $j(l)$ to $j(m)$ from the inequality in opportunity due to the circumstances $j(1)$ to $j(l-1)$.

Next, for each *j* and *l* let $A_{j,l}$ be implicitly defined as

$$p_i(j,l) = h\left(A_{j,l} + \sum_{k=j(l)}^{j(m)} f_k(X_{ki}) \right)$$

and

$$\bar{p} = \frac{1}{n} \sum_{i=1}^{n} p_i(j,l)$$

It is worth noticing that due to the nonlinearities it not necessarily true that

$$A_{j,l} = A + \sum_{k=j(1)}^{j(l-1)} f_k(\overline{X_k})$$

neither that, in general

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$$A_{j,l} = A + \sum_{k=j(1)}^{j(l-1)} \overline{f_k(X_{k\iota})}$$

Additionally, let

$$D(j,l) = \frac{\sum_{i=1}^{n}|p_i(j,l) - \bar{p}|}{n\bar{p}}$$

Notice that $D(j,l)$ isolates the contribution of circumstances $j(l)$ to $j(m)$ to the overall level of inequality of opportunity, D.

Furthermore, notice that if $j(l-1) = k$ then

$$\Delta(j,l) = D(j,l-1) - D(j,l)$$

is a measure of the contribution of circumstance k to the overall level of inequality of opportunity, D. Hence, a natural measure for the contribution of circumstance k, C_k, to the overall level of inequality of opportunity, D, is given by the average of these particular measures, i.e.,

$$C_k = \frac{1}{m!}\sum_{l=1}^{m}\sum_{j:j(l-1)=k} \Delta(j,l)$$

Finally, it is worth noticing that

$$D = \sum_{k=1}^{m} C_k$$

Hence, we have obtained a proper decomposition of the overall inequality of opportunity by source.

To simplify the computations it is worth noticing that if $j^0(l)$ to $j^0(m)$ and $j^1(l)$ to $j^1(m)$ are permutations of the same circumstances then

$$D(j^0,l) = D(j^1,l)$$

and more importantly, at least as far as the computations are concerned,

$$A_{j^0,l} = A_{j^1,l}$$

Hence, the number of constants to be computed is not equal to *m.m!* as one would expect from the fact that there are *m* possible values for *l* and *m!* for *j*. Because

$$A_{j^0,l} = A_{j^1,l}$$

whenever, $j^0(l)$ to $j^0(m)$ and $j^1(l)$ to $j^1(m)$ are permutations of the same circumstances, number of constants to be computed is not equal to 2^m and it is always true that $2^m < m.m!$, for all $m>2$.

Appendix 2: Data sources

Below is a detailed description of each data source and which opportunities where selected from each one:

1.   Encuesta Longitudinal Primera Infancia (ELPI): This survey is focused on childhood development. It was conducted for the first time in 2010 and its target population is children born between 1th January 2006 and August 2009 (age 5 or less) living in Chile. It is representative for both rural and urban areas. It collects information about all household residents (family structure, education, employment and income), the specific person taking responsibility for the child (social security, health insurance, assets, pregnancy conditions) and other questions focused on the child (activities with the person taking responsibility , nutrition, toys, vaccines, day care or kinder garden attendance, biological father information). After this a psychologist performs a series of tests to evaluate the psychomotor, socio-emotional and physical development of the child (other instruments are used to evaluate the same aspects for the child´s caretaker and family environment). From this source of information all childhood development opportunities have been selected.

2.   Encuesta de Caracterización Socioeconómica Nacional (CASEN): This survey has been conducted approximately every two years since 1985. It is representative at the national, regional and urban/rural levels. It routinely collects information about household residents, dwellings, education, health, employment and income. Other issues such as migration, social policies, etc, are included on a case by case basis. Opportunities for children (age 14 or less) in Education and Housing have been constructed from this survey. In addition, the inclusion of an autobiography section in 2009, which contains information about circumstances for Adults (age above 30) has allowed us to use this survey for the purposes of analyzing Adults Opportunities. [7]

3.   Encuesta Nacional de Juventud (ENJ): This survey has been done since 1994 every 3 years. The objective of the survey is to generate updated data regarding Chilean youth (age 15-29). It gathers information about education, economic situation, political opinions, use of new technologies, sexual practices, religion and discrimination. All Youth Development Opportunities have been analyzed using this data source.

4.   Sistema de Medición de la Calidad de la Educación (SIMCE): This annual census evaluates different topics, specifically reading and mathematics, for students in 4th Basic, 8th Basic and 2nd medium (ages 9, 13 and 15, respectively). Its objective is to improve education quality and equity, reporting students performance and relating it to school and social context. It also gathers information about school principals (personal characteristics, professional background and educational program), teachers (professional background and fields taught), students (learning strategies, motivations and interests) and parents (education level, income, satisfaction with the school, etc.) using context questionnaires. Educational performance is divided into 3 levels: Initial, Intermediate and Advanced. For each circumstance group the

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[7] This circumstance includes location where the person born and grew up, parents employment status and education level, family structure and indigenous origin.

probability of obtaining an intermediate or higher performance level was used as a measure to represent educational basic opportunities.

Appendix 3: Sub-National Analyses and the Geometric HOI

One of the points which came out in the discussion above is that location is one of the important determinants of inequality of opportunity. Therefore we do a sub-regional analysis for the classification of households into rural, urban metropolitan and urban non-metropolitan.

In principle, if opportunities improved for each and every region of a country, then it also should improve when measured for the whole country. However, the HOI as defined in the preceding sections, based on the D-Index, does not have this property. A complementary measure to the HOI based on the D-Index (hereafter just HOI) is the Geometric HOI.

The geometric HOI (G-HOI) is the population weighted geometric mean of the circumstance-specific coverage rates. With the geometric HOI, the country's overall geometric HOI index is given by the population weighted geometric mean of the regional specific indices. As a consequence, the country index would always increase when the all regional indices increase. That is, the geometric HOI is sub-group consistent. Sub-group consistency is important in analyzing changes of the HOI at sub-national levels.[8]

Both the HOI and the geometric HOI are equality of opportunity adjusted coverage rates. In both cases, we could identify a penalty for inequality of opportunity. However, the way the penalty is estimated is different. In the HOI the penalty is the product of the dissimilarity index and the coverage rate. In the geometric HOI, the penalty can be easily identified by the difference between the overall coverage rate and the geometric HOI. In the case of equality of opportunity, the geometric HOI will coincide with the overall coverage rate.[9]

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[8] See Barros and Molinas (2011) for a more complete discussion of the geometric HOI. This section follows closely the discussion presented in Molinas and Barros 2011.

[9] In the case of the 28 indicators used in this study, both the HOI and the geometric HOI gives consistent results with a correlation coefficient of .98.

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Box 3: Empirically estimating the Geometric Human Opportunity Index

1. Estimate a separable logistic model on whether person i had access to a given basic opportunity as a function of his or her circumstances. For completing a given grade on time, a series of indicator variables for age are used. In all cases, the functions are linear in the parameters. From the estimation of this logistic regression, obtain coefficient estimates.

2. Given these coefficient estimates, obtain for each person in the sample the predicted probability of access to the basic opportunity in consideration, $\hat{p}_i$ based on the predicted relationship, $\hat{\beta}_k$,and a vector of their circumstances x_{ki}.

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

3. Therefore the Geometric HOI is,

$$GHOI = \prod_{i=1}^{n} p_i(x)^{w_i}$$

where $w_i = \dfrac{1}{n}$ or some sampling weights.

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Source: Barros, Molinas and Saavedra (2011).

We use the Geometric HOI (G-HOI) next to describe the sub-national analysis. The figure below presents the G-HOI for selected basic opportunities and Table 9 presents the results for the three regions for all indicators.

Figure 6: Sub-regional G-HOI results
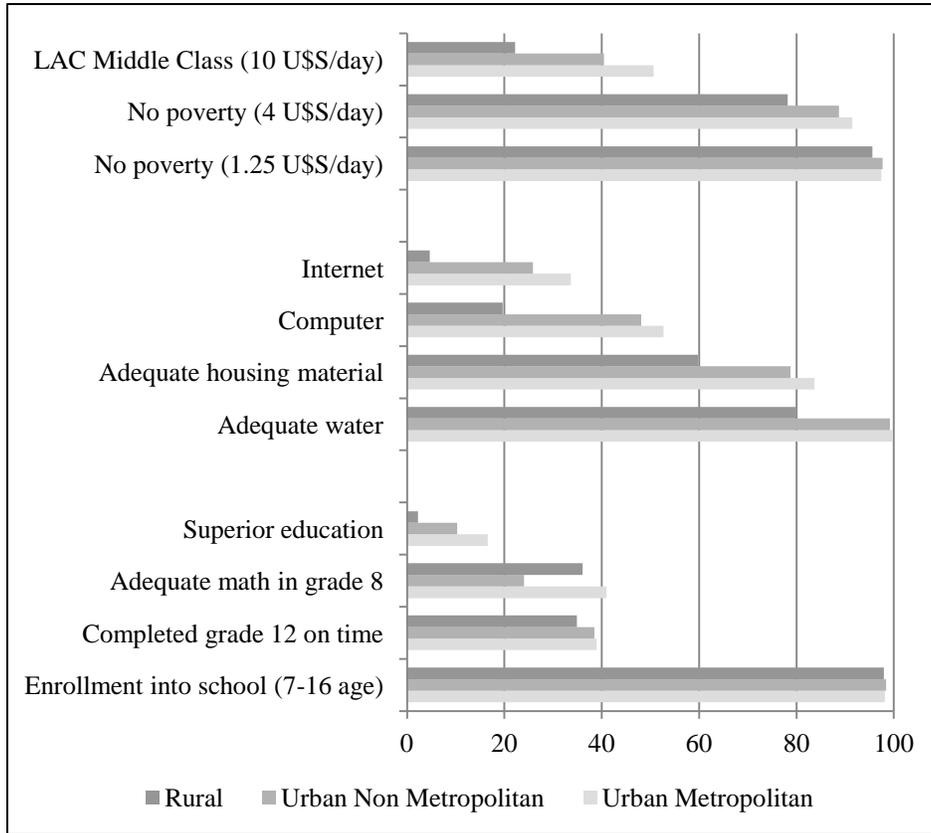
For a few basic opportunities that already achieve a higher G-HOI (greater than 80), there is little difference in the G-HOI across the three regions. Figure 7 illustrates that there is not big differences in the G-HOI in school enrollment, completion of 12th grade on time, and freedom from extreme poverty (international measure).

However, several G-HOIs for basic opportunities display notorious disparities across the regions. There is significant inequality across regions in adequate math learning in grade 8, access to superior education, access to water, adequate housing material, access to computer and internet, and access to the LAC middle class.

Table: Geometric HOI by Location

		Urban Metropolitan	Urban Non Metropolitan	Rural
1	**Early Childhood (0-5years)**			
a.	Cognitive			
i.	Inputs			
1	Parents involved with child	71	73	68
2	Adequate toys	69	59	44
3	Child attends pre-school	75	71	45
ii.	outputs			
1	Adequate socio-emotional development	81	76	78
2	Adequate psychomotor development	89	89	81
3	Adequate vocabulary	75	75	60
b.	Health			
i.	Normal birth weight	84	84	82
ii.	Adequate height-for-age	85	85	85
2	**Education**			
a.	Attendance			
i.	Enrollment into school (7-16 age)	98	98	98
ii.	Completed grade 12 on time	39	39	35
b.	Learning			
i.	Adequate reading in grade 4	68	59	68
ii.	Adequate math in grade 4	66	51	65
iii.	Adequate reading in grade 8	65	56	63
iv.	Adequate math in grade 8	41	24	36
3	**Youth development**			
a.	Cognitive			
i.	Read	52	43	38
ii.	Participate in political process	48	54	47
b.	Health			
i.	Play sports	54	50	50
ii.	Free from illegal consumption	90	93	96
iii.	Safe sexual practices	76	75	73
4	**Housing**			
i.	Adequate water	100	99	80
ii.	Adequate sanitation	99	97	63
iii.	Adequate housing material	84	79	60
iv.	Computer	53	48	20
v.	Internet	34	26	5
5	**Adults**			
i.	Superior education	17	10	2
ii.	No poverty (1.25 U$S/day)	97	98	96
ii.	No poverty (4 U$S/day)	91	89	78
iii.	LAC Middle Class (10 U$S/day)	51	40	22

For most basic services, we see that G-HOI is lower for the rural areas than for the urban areas. However the difference stands out in the case of access to sanitation and water where rural areas have significantly lower G-HOIs than in urban centers. Only in the case of adequate math learning the G-HOI for rural areas is higher than that observed for non metropolitan urban areas.

For several basic opportunities we also see that there are large differences in G-HOIs between urban metropolitan and urban non-metropolitan areas. As is evident from the figure above urban metropolitan areas have the best G-HOIs in all indicators. Differences in the G-HOI across metropolitan and non-metropolitan urban areas are significantly large in adequate math learning in grade 8, access to superior education, and access to the LAC middle class.

Appendix 4: The Relationship between the Multidimensional HOI and Joint Probabilities Approach.

We explore to what extent the product of the probabilities of access to each of the component basic opportunities provides a good approximation to the true multidimensional indicator. For example in the case of two basic opportunities A and B, the probability of access are p(A) and p(B). Therefore the joint probability of access to these two basic opportunities A and B (p(A and B)) is given by the product of their individual probabilities (p(A) . p(B)). However this assumes that the probability of access to A is independent of the probability of access to B.

If the probability of access to A is not independent of the probability of access to B the true probability of joint access to A and B would not be the product of the individual probabilities of access (p(A) . p(B)). If the basic opportunities were complementary, in the sense that having one implied that it was more likely to have the other, we would see that the joint probability will be larger or equal to the joint probability with respect to the case of independent probabilities.[10] Therefore if our assumption about independence of access is not correct and if the basic opportunities are in fact complementary, our calculation will give us a *lower* bound of the true joint probability of access.. Similarly in some cases it may be more likely that the opportunities are substitutes for each other, in the sense that having one implies it is less likely to have the other one. In this case the multidimensional HOI measured using our method of the product of single probabilities will be higher than the true multidimensional HOI

Below we explore how well the method of using the product of individual probabilities approximates the true multidimensional HOIs considered above. The table below presents the approximations of multidimensional HOIs based on the product of probabilities approach.

Table 10: HOI for Multidimensional Indicators (Product of Probabilities)

	Coverage	Penalty	HOI	D-Index
Multidimensional Indicators				
Early Childhood Development	51	6	44	12
Adequate Learning	20	5	15	24
Youth Development	37	4	33	12
Core Housing	73	7	66	9

Source: Authors' calculation based on ELPI 2009, ENJ 2009, and CASEN 2009.

From this estimation exercise with the product probability approach, it appears that the method works well when there are solid empirical grounds supporting the complementarities of the indictors involved. Solid grounds in this context refer to positive, relatively strong and statistically significant correlation coefficients among the variables involved. To have a deeper

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[10] We have that $p(A \text{ and } B) = p(A).p(B/A) \geq p(A).p(B)$.

understanding of what constitute in this context "relatively strong" correlation coefficients and a reliable "rule of thumb" is an area which requires more empirical work. For this simple exploratory exercise, it appears that a correlation coefficient of 0.6 or higher might be a relative safe initial rule of thumb to use.[11]

The multidimensional HOI for early childhood development considering independency among the probabilities of access of the three indicators is 44, as presented in Table 10. Are these three indicators comprising the multidimensional indicator complements or substitutes of each other? Looking at the correlation matrix for these three indicators can be informative. For complementary indicators we should see a strong and statistically significant positive correlation coefficient. For substitute indicators we should also see a strong and statistically significant negative correlation coefficient.

Table 11: Correlation Matrix among Early Childhood Development Indicators.

	Socio-emotional Development	Psychomotor Development	Vocabulary
Socio-emotional Development	1	0.39*	0.77*
Psychomotor Development		1	0.69*
Vocabulary			1

Source: Authors' calculation based on ELPI 2009.

From the correlation matrix above we observe positive, statistically significant but not always strong correlation coefficients among the variables for the multidimensional indicator for early childhood development. The correlation coefficient between adequate psychomotor and socio-emotional development seems not to be very strong. It seems that if there is some complementarity between these two indicators, it is a weak one.

When comparing the approximated multidimensional HOI to the true multidimensional HOI in early childhood development, the result is not as expected. On the assumption of complementarity, the approximated multidimensional HOI was expected to be equal or lower to the true multidimensional HOI. In this case, the approximated multidimensional HOI is 44 whereas the true multidimensional HOI is only 31. Thus we may conclude that it seems that if the correlations are not strong enough among the individual indicators the method of product probabilities might not render estimates as expected.

The multidimensional HOI for adequate learning approximated taking into account independence of the probabilities of access of the two indicators is 15 (Table 10). Are these indicators complements? Table 14 presents the correlation coefficient.

Table 12: Correlation Matrix between Adequate Learning Indicators

	Reading in Grade 8	Math in Grade 8
Reading in Grade 8	1	0.76*
Math in Grade 8		1

Source: Authors' calculation based on CASEN 2009.

When comparing the approximated multidimensional HOI to the true multidimensional HOI in adequate learning, the result is as expected. We observe a positive, relatively strong and statistically significant correlation coefficient between the two variables considered. Therefore, it seems that the two indicators are complementary and the multidimensional HOI for adequate learning obtained by the product of individual probabilities, assuming independence, should be considered as a lower bound of the true multidimensional indicator. This is exactly what we observed; the approximated indicator (15) is lower than the true indicator (29).

The multidimensional HOI for youth development approximated with the product probability methodology is 33 (Table 10). Are the three indicators considered complements? Table 15 presents the correlation coefficient.

Table 15: Correlation Matrix among Youth Development Indicators

	Participation in Political Process	Free from Illegal Consumption	Safe Sexual Practices
Participation in Political Process	1	-0.14	0.64*
Free from Illegal Consumption		1	0.21*
Safe Sexual Practices			1

Source: Authors' calculation based on ENJ 2009.

From the correlation matrix above we are not sure these three indicators are complements. We observe a negative but not statistically significant correlation between participation in the political process and free from illegal consumption. A positive but weak correlation between free from illegal consumption and safe sexual practices. A positive, statistically significant and relatively strong correlation between participation in the political process and safe sexual practices. Overall, we do not have enough empirical evidence clearly supporting complementarity or not among this set of indicators. Therefore, we cannot be sure to expect the approximated multidimensional HOI to be either underestimating or overestimating the true multidimensional HOI.

The multidimensional HOI for core housing approximated with the product probability methodology is 66 (Table 10). Are the three indicators complements? Table 16 presents the correlation coefficient.

Table 16: Correlation Matrix among Housing Indicators

	Water	Sanitation	Adequate Housing Materials
Water	1	0.98*	0.70*
Sanitation		1	0.80*
Adequate Housing Materials			1

Source: Authors' calculation based on CASEN 2009

When comparing the approximated multidimensional HOI to the true multidimensional HOI in core housing, the result is as expected. We observe a positive, relatively strong and statistically significant correlation coefficients among the three variables considered. Therefore, it seems that the three indicators are complementary and the multidimensional HOI for core housing obtained by the product probabilities approach should be considered as a lower bound of the true multidimensional indicator. This is what we get; the approximated indicator (66) is lower than the true indicator (69).