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Rafael Guerreiro Osorio**

1 INTRODUCTION

Although the Millennium Development Goals are global, in the sense that they are to be reached by the whole world,[1] not necessarily by countries individually, in many countries the true commitment to them has led many to ask the question: will my country reach all or some of the MDGs by 2015? Are we on or off track? If off track, how far are we? To answer this question it is mandatory to perform some kind of projecting exercise. We talk of projections, not of forecasts,[2] for there are many variables that can intervene to determine the performance of a country in its pursuit of the goals. Furthermore we have to deal with the fact that we cannot really predict what is going to happen up to 2015, but just make assumptions.

However, projections can indeed be so accurate as to resemble forecasts. This is the case when there is plenty of data available, as well as technical expertise in projecting, and time. Unfortunately, this is seldom the case, particularly in developing countries. The common situation faced by those who ask the question on whether the MDGs will be reached by a certain country by 2015 is that of scarcity of data and/or of technical skills.

In this paper we discuss simple projection techniques to be used in these contexts of scarcity of data and/or of technical skills. These projections can be done using standard spreadsheet software and already calculated MDG indicators that are made available, for instance, by international organizations. In order to do so, we first review the basic steps of any projecting exercise. Then we evaluate and compare the alternatives we have for projections when only aggregated national indicators for a few points in time are available. In the last section, we deal with the problem of projecting indicators broke-down by groups, such as those defined by, among others, gender, race/ethnicity or income brackets. To address this problem, we developed a projection technique based on Kakwani's achievement function (Kakwani, 1993) that can be easily implemented in any spreadsheet, and give some examples of its applications. We end the paper offering some concluding remarks on the alternatives for projecting the MDG indicators discussed and developed throughout the paper.[3]

2 THE BASICS OF PROJECTIONS

Generally speaking, projecting involves two steps. The first one is to gather knowledge of what happened from past to present. The second one is to make assumptions of what will happen from present to future. Second step is usually accomplished under the lights shed by the information we got on the first step.

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Let the common exercise of projecting population size be an example. The proximate determinants of future population are: the current size; the number of people entering the population, given by births and immigration; and the number of people exiting the population, given by emigration and deaths. Population size is then related to fertility, migration and deaths. If we had a complete and perfect set of past data to put under scrutiny, we could develop a model to explain how fertility, migration, and deaths altogether influenced the population dynamics in a given period. Then, the growth pattern represented by the model could be deployed to project the future population size.

The obvious problem is that the model, no matter how good it depicts the driving forces of past population growth, might not be able to account for future changes, and that can render its predictions untrue. The farther away in time is our projection, the higher is the likelihood that it is flawed. That is why the more precise models of population growth, instead of assuming that the trends of fertility, migration, and deaths will keep unchanged, substitute past rates by hypothetical rates that represent the expectations that current knowledge leads us to bear upon the future behavior of these factors.

However, as any demographer would agree, projecting population size is not that easy (Haub, 1987). Seldom is a perfect and complete set of past data available. One should add to the ever present data problems the fact that the expectations about the future behavior of fertility, migration and deaths, that seemed reasonable when the projection was made, might be overcome by unpredictable factors, like natural catastrophes, wars, epidemics, just to name a few extreme ones. Lack of good data and unpredictable behavioral changes or events are always the biggest obstacles to be surpassed.

In the case of the MDG indicators, the only information available frequently is the indicator itself for a few points in time. But when we think of the MDGs, additional difficulties arise because many of the indicators regard realms of the social life that are so complex, such as gender, that it would be hard to develop a model of their behavior even if we had plenty of data.

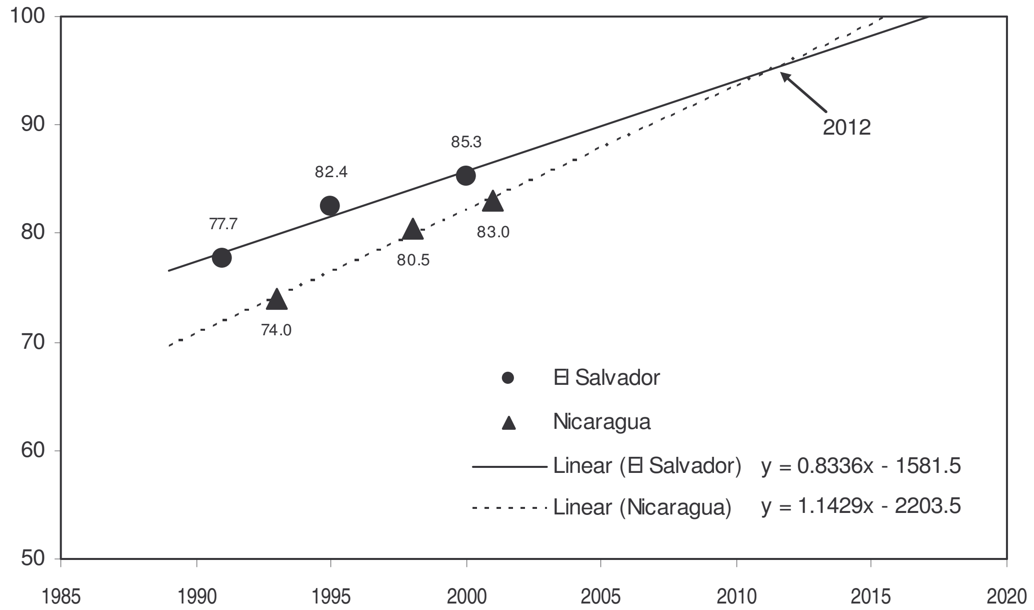
3 ALTERNATIVES FOR PROJECTING AGGREGATED NATIONAL INDICATORS

To project the MDG indicators we have to deal with the problems of the lack of data and of the complexity of the underlying social processes. Explicitly or implicitly the strategy to accomplish this difficult task has been laid over the assumption that in the relatively short period up to 2015 the performance of the countries will be the same as in the relatively short period before the present. This can be seen as the main reason why most of the reports that try to answer whether the MDGs will be achieved by 2015 rely in simple linear projections of the indicators, no matter how rich they can be bringing forth additional data and detailed information on policies. Let’s evaluate whether this is a good strategy.

We will take as an example the net attendance ratio in primary education, the main indicator to monitor the progress towards the third target of the second MDG—ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling. We can turn to a trustable source of national MDGs indicators such as the Equity and Social Indicators—EQxIS—from the Inter-American Development Bank to get the net attendance ratio,[4] say, for El Salvador and Nicaragua. Browsing through EQxIS we find out that this indicator is available for three points in time for Nicaragua, and for five points in the case of El Salvador. For the sake of this initial example, we will consider just the first three points available for El Salvador.

CHART 1

Net Attendance Ratio in Primary Education—Observed Points and Linear Trends. El salvador and Nicaragua



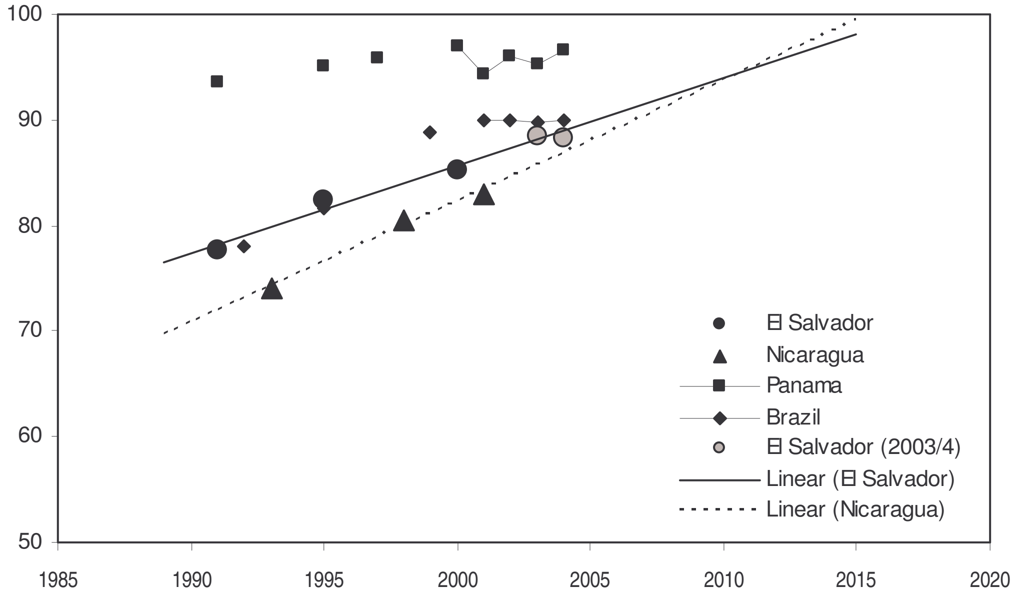
Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

To make Chart 1 above we just copied the data from the EQxIS website and pasted to standard spreadsheet software. Most of these applications have some way of plotting a trend curve for a series of charted data points. In Chart 1, we "ordered" a linear trend When we did so, the software considered the indicator (y axis) as a dependent variable, and the years (x axis) as an independent variable, and regressed one on the other using the ordinary least squares method to find out the slope and the intercept of the line that is closer to all three points, and then draw it. The benefit of asking the spreadsheet software to do the job for us is that we do not need to know all the mathematics required to fit the line.

Technicalities aside, Chart 1 helps us to understand some of the problems of using a linear trend for projecting an indicator. If we were to believe in the projections presented on Chart 1, we would come to the conclusion that both El Salvador and Nicaragua would be very close to reaching a net attendance ratio of a 100% by 2015. And by 2012, Nicaragua, which had lower levels of net attendance, would outperform El Salvador, which departed from higher levels. The question now is whether these conclusions are realistic. The straightforward answer comes from Chart 2: no, they are not.

CHART 2

Net Attendance Ratio in Primary Education—Observed Points and Linear Trends. El Salvador, Nicaragua, Panama and Brazil



Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

For El Salvador, we plotted the two additional points, 2003 and 2004, which we intentionally set aside from Chart 1. We can see that although 2003 seems to be right on the trend line, 2004 is a little below it. Indeed, the net attendance ratio of 2004 is slightly smaller than that of 2003, a difference that can be attributed to sampling errors (this can be verified by accessing the statistics of significance that are made available by EQxIS). However, if we pay attention to the sequences that represent the evolution of the net attendance ratios in Panama, which has one of the highest rates among the Latin American countries, we can see that after a certain level of attendance is reached, further improvements become harder to achieve. The same happens for the Brazilian series we added to Chart 2, although at a lower level.

In the real world, hardly any policy, no matter how good, will cover everyone that is entitled to benefit from it. The case of primary education is a fair illustration of this problem. Our indicator, the net attendance ratio, is the share of the population of a given age bracket—that varies from country to country, but it is usually from 6 to 11 years-old—that were attending primary school. But not even in a perfect educational system all children of the specified age will be attending primary education. For instance, some of them might have entered primary education one year earlier and reached its completion moving to secondary education at an age in which most of the others are still in primary. Supposing those pupils represent 5% of the population targeted for primary education, a net attendance of 95% would be outstanding (the gross attendance for that age-bracket would be a 100%). Some countries might as well allow home schooling, and if this is the case, the net attendance will not ever reach a 100%. Also, part of the children might have severe disabilities that prevent them from attending school. And so, a net attendance rate of less than a 100% is not necessarily something to be worried about, once we know the circumstances that place it at a lower level.

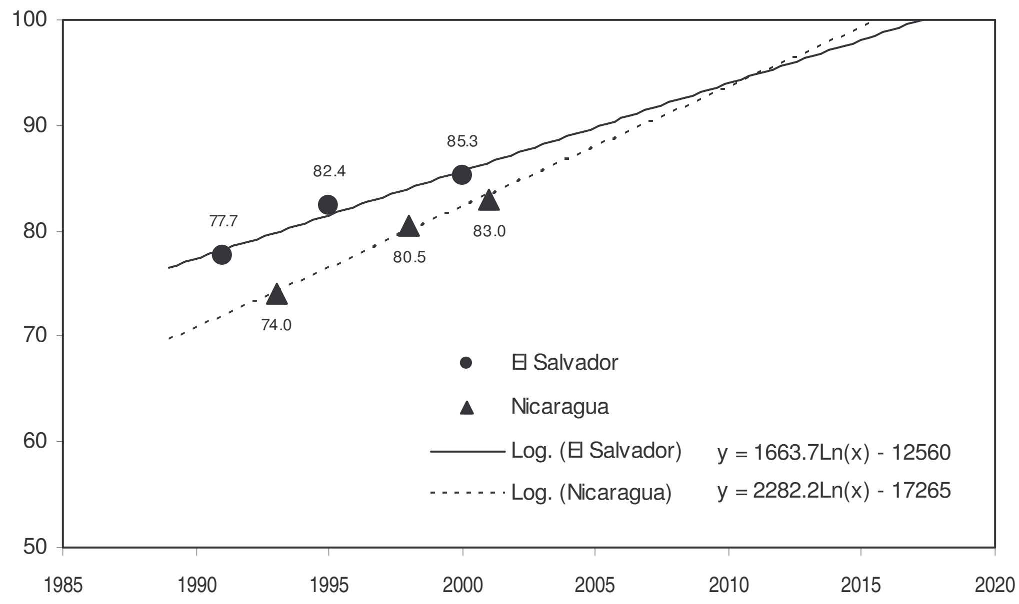
However, most likely the problem of surpassing a certain level of net attendance will be related to the well known fact that all policies, particularly those which are intended to be universalized, face a common challenge: it is easy to increase the coverage when you depart from very low levels, but there's a point from which further improvements require great investments and lots of effort. Following our example, some children that are not attending might be out of school because they live in distant areas, where there are neither schools nor teachers—it might be the case that there are no roads to get there, and so they could not even be transported to a "nearer" school.

Often the expansion of a social program begins by, not surprisingly, reaching the easy to reach—then the growth pace of its coverage will be progressively reduced. Higher efforts will be needed to sustain growth as the coverage level increases. Therefore, our projections must take this into account. And, definitely, linear trends don't account for that, because they carry on the implicit assumption that further improvements will be achieved as easily as past improvements were.

When dealing with "positive" indicators, that is, those for which the more the better, such as the net attendance ratio in primary education that we took as an example, concave functional forms would account for the idea that the higher the level, the harder will be to reach further improvements. Unfortunately this leaves us with only one straightforward option if we still want to use the trend curves that most spreadsheet applications are able to fit to the data points of a series in a chart. This option is shown on Chart 3, in which we reproduced Chart 1, this time fitting logarithmic trend curves to our data.

CHART 3

Net Attendance Ratio in Primary Education—Observed Points and Logarithmic Trends. El Salvador and Nicaragua

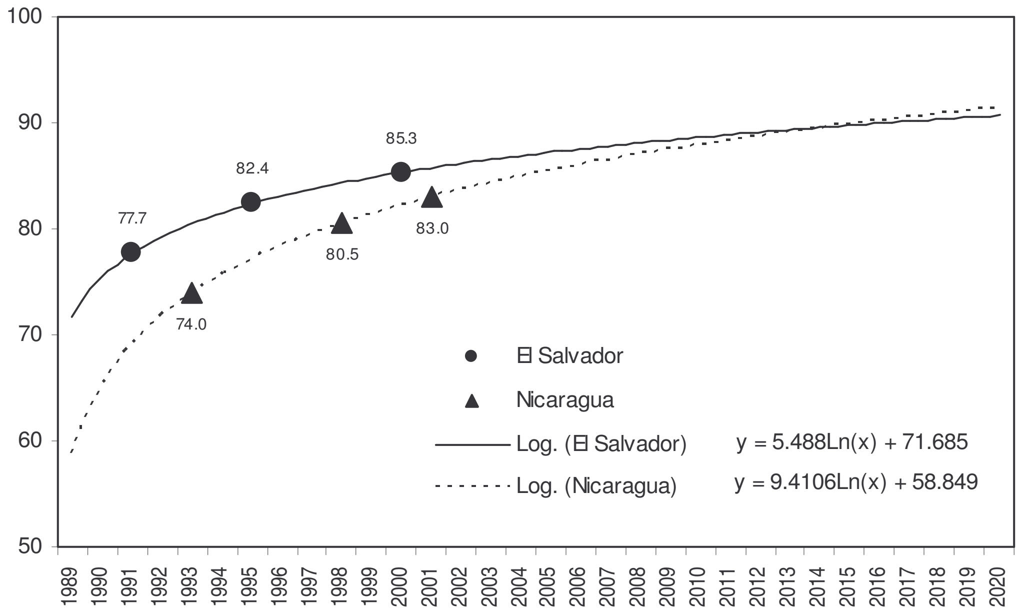


Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.org/xindicators).

What went wrong? Did we "order" a logarithmic trend and got a linear trend? Not really. The problem with Chart 3 is the magnitude of the values in the x-axis, the years, which the spreadsheet application treated as an independent variable to fit the trend curve. The logarithmic function is a concave curve, but as the difference between the differences of the logarithms of the years is very small at this magnitude, we get almost the same result we got with the linear trend. We will get back to this point and clarify it in the next section. By now, all we need to know is that in order to correct this problem, we have to substitute the actual years by their position in our series, so that 1989 becomes year 1, 1990 year 2, and so forth. By doing that, the difference between the logarithms of each "year" varies enough and becomes significantly smaller as we approach the end of the series. The result of this change can be seen on Chart 4.[5]

CHART 4

Net Attendance Ratio in Primary Education—Observed Points and Logarithmic Trends (Years' Position as Independent Variable). El Salvador and Nicaragua

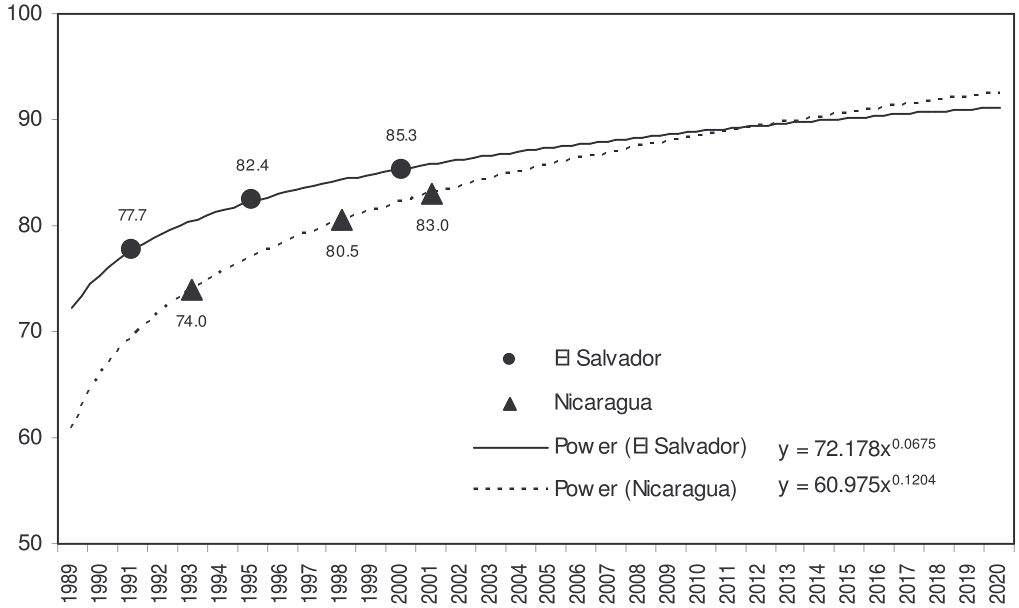


Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

Now we got a more realistic projection that incorporates the idea that once higher levels of net attendance in primary education are reached, further improvements become harder. Before we move on, however, it is worthy of mention that although the logarithmic trend was our straightforward option, for we knew in advance that this is a concave function, there was in fact another option. For an independent variable in the same range of values, {1, 2, 3, 4…}, and a positive indicator expressed as percentage, the power function behaves similarly to the logarithmic function. This can be seen on Chart 5.

CHART 5

Net Attendance Ratio in Primary Education—Observed Points and Power Trends. El Salvador and Nicaragua

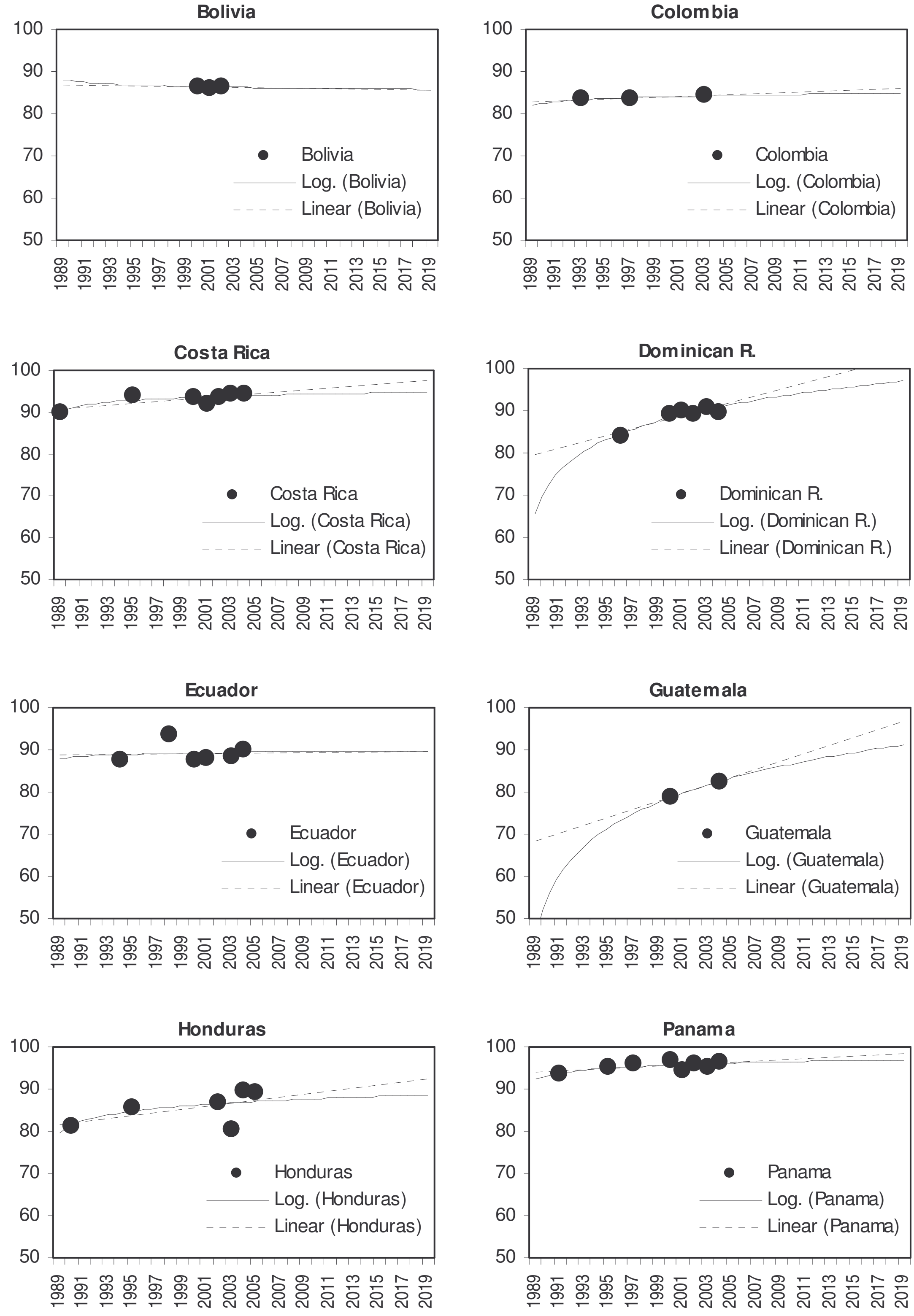


Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

At last, on Chart 6, we see the national net attendance ratios of some selected Latin American Countries, and the linear and the logarithmic trend curves that project the evolution of the indicator up to 2020. Looking at the differences between linear and logarithmic trends, we can distinguish three groups of countries. The first group, comprised of Bolivia, Ecuador and Colombia, shows a stable net attendance ratio, and this makes the linear and the logarithmic trends almost undistinguishable. Our second group is comprised of Costa Rica and Panama. In these two countries the net attendance ratio increased a little, but it was already at a very high level, above 90%. For them, the logarithmic trend yields slightly more conservative results than the linear one, which in our view are more reasonable under the lights of the axiom of the increasing difficulties to improve an indicator as higher levels are attained. Our last group includes the Dominican Republic, Guatemala and Honduras. These are countries which experienced substantive improvements in the net attendance ratio level. For these, the linear trends are very optimistic, differing significantly from the logarithmic trends which are far more conservative.

CHART 6

Net Attendance Ratio in Primary Education—Observed Points, Linear and Logarithmic Trends. Selected Latin American Countries



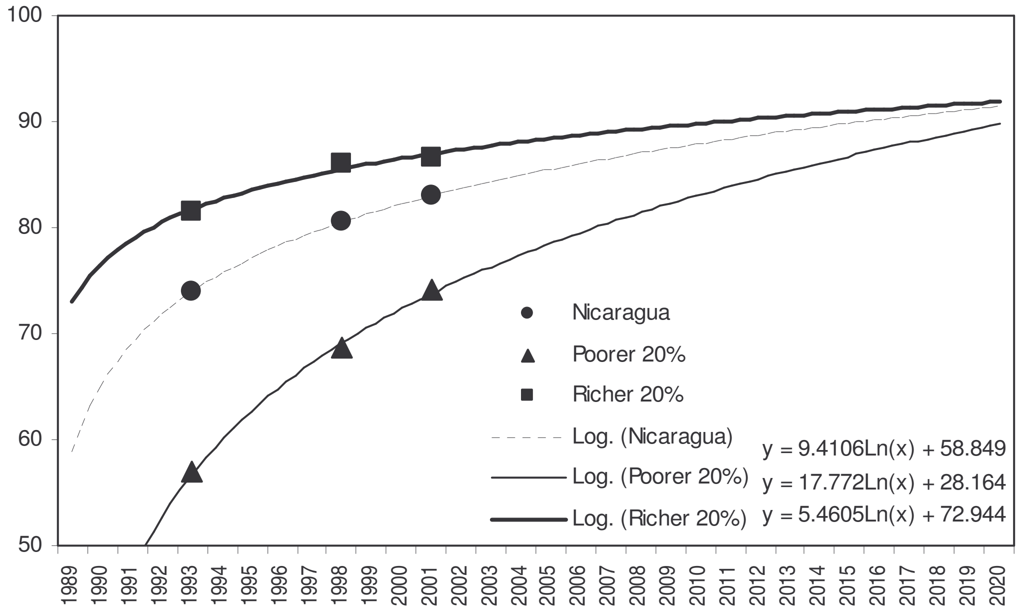
Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.org/xindicators).

4 PROJECTING DISAGGREGATED INDICATORS

On the previous section we got fairly good results using a logarithmic instead of a linear trend to project the net attendance ratio. In most of the cases, the projections obtained were in accordance with the common sense assumption that it is harder to raise even more the level of an indicator when it is already high than to raise it when it is low. The logarithmic trends were always more conservative than the linear trends, even for those countries where the indicator was stable, and the trends were almost undistinguishable. The question now is whether this simple technique will also prove itself good to project a disaggregated indicator. In Chart 7, we used logarithmic trend curves to project the net attendance ratio of Nicaragua disaggregated by income quintiles—we chose to plot just the bottom 20% (the poorer population group) and the top 20% (the richer). Just for comparison, we added the national figures to Chart 7 as well.

CHART 7

Net Attendance Ratio in Primary Education, National, Bottom and top Quintiles—Observed Points and Logarithmic Trends. Nicaragua



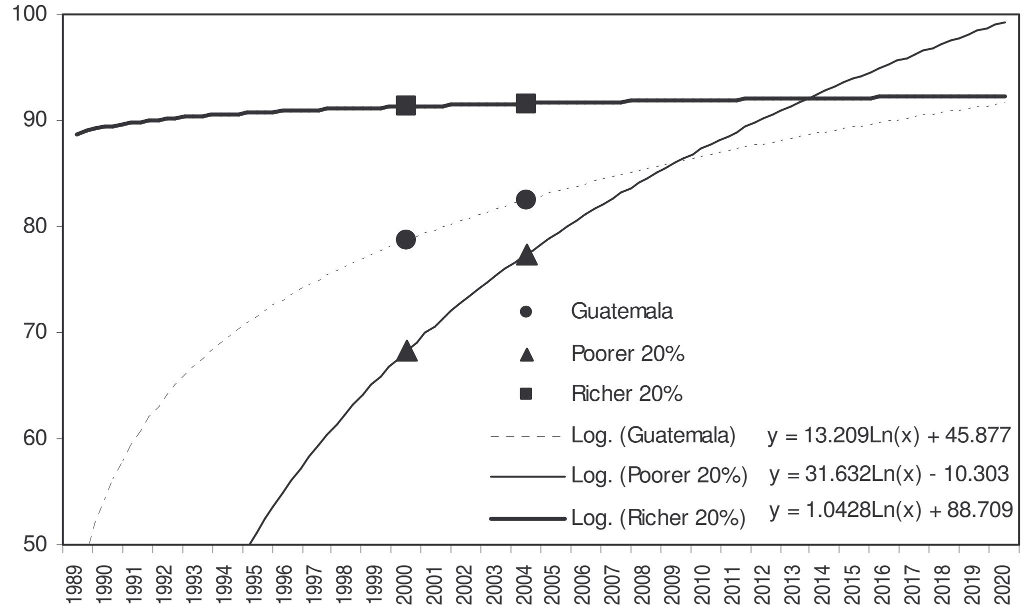
Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

The result of the projecting exercise depicted in Chart 7 is good in the sense that it does not contradict our intuitive feelings about inequality. In other words, for the period represented, 1989-2020, the net attendance ratio of the richer group lies above the national one, which in turn lies above that of the poorer group.

However this will not hold for every situation. As we can see from Chart 8, if we do the same using data for Guatemala, even with a logarithmic trend curve the net attendance ratio of the bottom 20% would soon surpass the national average, and by 2015 they would be even better off than the top 20%! Soon after 2020 the indicator of the poorer would be way above a 100%. It is needless to insist that such a projection is not realistic at all, and that we should pursue a better alternative.

CHART 8

Net Attendance Ratio in Primary Education, National, Bottom and top Quintiles—Observed Points and Logarithmic Trends. Guatemala



Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

Up to this point we have been avoiding getting into the mathematics behind the trend curves—because the spreadsheet is able to do that for us. Unfortunately, to better understand the problem that puzzles us we need to briefly examine the functional forms we have been dealing with to find out where the catch is. Formulas 1 to 3 below are, respectively, for the linear, the logarithmic, and the power trends.

$$f(x) = ax + b \qquad [1]$$

$$f(x) = a\ln(x) + b \qquad [2]$$

$$f(x) = bx^{a} \qquad [3]$$

Where f(x) stands for the predicted value of the indicator (the net attendance ratio in our example); x is our independent variable, the year (its position in the series for [2] and [3]); and *a* and *b* are the parameters that define a particular trend curve, like that of the poor and that of the rich.

On the linear function, *b* is the intercept, it represents the value of the indicator in year zero, when the line intercepts the y-axis—easy to see that if x equals zero, f(x) equals *b*. So *b* gives information about the initial level. However, if x equals zero, the logarithmic function is not defined, for zero has no logarithm; and as zero raised to any power is zero, the power function would equal zero, not *b*.[6] Nevertheless, *b* also provides information about the initial level in the logarithmic function: when x equals one, that is, for the first year in the series, f(x) equals *b* because the logarithm of one is zero. The same happens in the power function: as one raised to any power is equal to one, when x equals one, f(x) equals *b*.

While *b* represents the initial level at year zero or year one, *a* can be interpreted in our case as a "performance" indicator. For the linear function, *a* gives us an absolute rate of change: at year 1 the predicted value would be $a+b$; at year 10, $10a+b$; and so on.

In the logarithmic function *a* plays the same role, but as a constant relative rate of change. The spreadsheet obtains its parameters exactly in the same way it does for the linear function, using ordinary least squares to fit a line. The functions differ in shape because we apply the logarithmic transformation to the position of the year in the series: the independent variable becomes the logarithm of the position of the year, and its relationship to the dependent variable is linear. By doing so, instead of having a constant one year difference between any two years, we have the differences between their logarithms, which decrease as the years increase so as to maintain the same relative rate of change: $\ln(2) - \ln(1) = 0.693147$, and $\ln(13) - \ln(12) = 0.080043$, but $\ln(24) - \ln(12) = 0.693147$ (because 24/12=2/1). The "trick" behind the logarithmic trend curve, therefore, is to calculate the predicted value for a point as though it was closer to the previous point than it is, and then plot it in its real position: not at ln(2), but at 2. That's why we did not get a good result in our first try on Chart 3: using the years instead of the position of the years in the series, we set our independent variable at a magnitude in which the differences between logarithms is almost constant. For instance: $\ln(1990) - \ln(1989) = 0.000503$, and $\ln(2001) - \ln(2000) = 0.000500$.

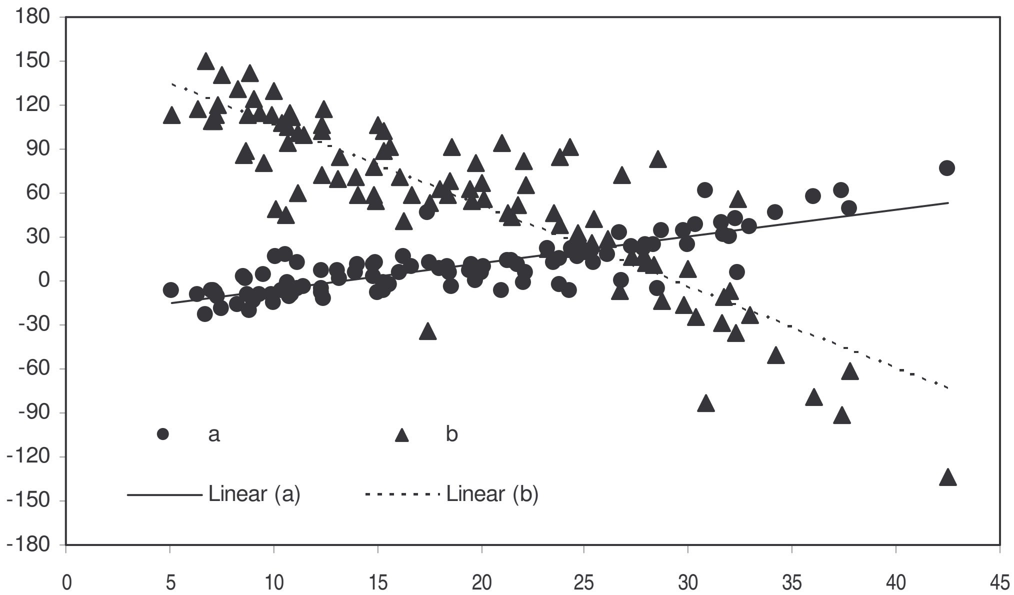
In the power function, *a* is also a "performance" indicator, and it determines the pace of change as in the two previous functional forms. The power function, however, is not always concave, only when *a* is a number between zero and one (that is, when we are taking roots). But what matters here is that, for all practical purposes, the power function does its "trick" in the manner of the logarithmic function. It takes some root of x, such as the square root ($a = 0.5$), and multiplies this by *b* (the initial level). The differences between differences of the roots of the position of the years decrease as we move towards the end of the series—so again we predict the values for points that are increasingly closer to the previous point, but when plotting them we do so at constant one year distances, and that is how we get the concave shape. For instance: $2^{0.5} - 1^{0.5} = 0.414213$, and $13^{0.5} - 12^{0.5} = 0.141450$.

If we take another look at Charts 1, 3, 4, 5, 7 and 8, in which the equations of the trend curves are shown, it is easy to see that the value of *a* is always greater for the countries or the groups within countries that departed from lower levels of net attendance. This is in accordance with the axiom that the higher the level of the indicator, the harder are further improvements. However, it is now clear that we are not thoroughly incorporating this idea in our projections. Even when we used power or logarithmic trends the curves were fitted for a constant *a*, therefore assuming constant "performance". While we were dealing with a national indicator, this was not an issue at all. For the concave trend curves, particularly the logarithmic, yielded reasonable results. However, as we have seen in Chart 8, if we have more than one group departing from very different levels, the trend curves fitted might lead us to unrealistic conclusions.

Let's take advantage of the fact that EQxIS provides the same indicator for many population groups. Our example, the net enrolment ratio in primary education, is often available for more than one hundred groups. This helps us to put under deeper scrutiny the question of decreasing performance. In order to do so, first we obtained from EQxIS the 2000 and 2004 net attendance ratios for 97 distinct population groups (defined by income quintiles, gender, ethnicity and territorial divisions) of Guatemala.[7] Then, for each group we calculated the parameters *a* and *b* of a logarithmic trend curve; and we also calculated the linear distance of the 2000 level from the logical upper bound of the net attendance ratio, which is a 100%. The result of this exercise is shown on Chart 9.

CHART 9

Variation of the Slope (a) and of the Intercept (b) of Logarithmic Trend Curves. Guatemala



Source: Author's calculations based on data from the Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

The x-axis of Chart 9 represents the distance of the net attendance ratio from the logical upper bound in 2000. The y-axis represents the values assumed by *a* and *b*, given the change from 2000 to 2004. Chart 9 is an empirical confirmation of the axiom we have been dealing with. The value of *a*, which is our "performance" indicator so far, decreases as the departure level of the net attendance ratio becomes closer to its logical upper bound (leftmost values are closer to the upper bound). On the other side, the value of *b* increases, because the groups with higher net attendance ratios departed from a higher level. Finally, both *a* and *b* assume negative values. For the former, because when levels closer to the logical upper bound of the indicator are reached, the indicator might decrease due to sampling errors. On one point it might be 92.5%, and in the next 92.1%, not because the net attendance ratio decreased, but because an indicator calculated from household surveys is affected by their sample designs. For the latter, it is because of the functional form we are imposing to the data: a negative net attendance ratio does not make any sense at all.

Summarizing, we have two problems to project a disaggregated indicator. The first one is related to the fact that up till now, our projecting techniques do not deal with the fact that the indicators, at least the well behaved ones, have logical lower and upper bounds. For instance, a net attendance ratio must be in the 0 to 100% interval. This problem is relatively easy to solve. The second problem is a bit more complicated and has to do with incorporating the idea that we have to increase the efforts to achieve universal coverage once higher levels are attained.

Let's think then of a hypothetical country that, in a given period, succeeded in improving the level of the net attendance ratios in primary education of three population groups. Group A departed from a very low level, 10% and reached 50%. Group B went from a considerably higher departure level, 80%, to 90%. And group C succeeded in raising an already very high level, going from 95% to 98%. How do we evaluate the performance of the country regarding these three groups? If we were to do it using one of the already discussed functional forms taking the pace of growth, represented by *a* in equations [1], [2], [3], as the "performance" indicator, there would be no doubt: the effort to improve A's situation would have been higher than for B, which by its turn would have been subject of greater efforts than C. We could then say that our hypothetical country is very fair, given the fact that it does more effort to improve the situation of the worst off groups. Our projections would then lead us to conclude that in a near future, the groups would be equalized (and, as we have seen on Chart 8, soon the worst off groups would be even better than the actual better off group).

However, if we think of the axiom we want to incorporate in our projections, we need a tool that would classify the degree of effort in reverse order. In our country much more effort was put into the improvement of group C, which experienced the growth of an already very high net attendance—something that it is hard to accomplish, as we can empirically confirm with ease (see Chart 9, which can be reproduced for other countries as well). A little less effort was put on the improvement of group B; and not much effort was required to raise the net attendance of group A. And now we can think of this country as being extremely unfair, because it did more effort to help the better off group.

Of course, this is all a matter of judgment. We cannot know the real degree of effort just by looking at the evolution of an indicator. But we need to make assumptions about it for our projections. If we had some function that incorporated the notion of performance indicated by effort as we just described, most likely projections done using it would yield results that would not be counter-intuitive to our perceptions about inequality. These projections would preserve the original ranking between groups.

Fortunately, these issues have been dealt with before, and such a function has already been developed by Kakwani (1993). For reasons distinct from ours, Kakwani sought to develop a class of functions that would allow comparisons between countries based on the evolution of standard of living indicators with very different starting levels. He set forth a transformation of the original indicators by what he named as achievement function. This achievement function transforms an indicator according to three distinct parameters: a lower bound, an upper bound, and a parameter that represents the inverse of how hard it is to convert additional effort into results. If the parameter is zero, we have a bounded linear trend, meaning that going from 80% net enrollment to 85% takes the same effort as going from 90% to 95%. If the parameter is unity, bounded proportional increases take the same effort. After some derivations, Kakwani (1993:314) arrives at the two following formulas for the class of achievement functions.

$$f(x,U,L)=\frac{(U-L)^{1-e}-(U-x)^{1-e}}{(U-L)^{1-e}} \quad \text{for } 0<e<1 \tag{4}$$

$$f(x,U,L)=\frac{\ln(U-L)-\ln(U-x)}{\ln(U-L)} \quad \text{for } e=1 \tag{5}$$

Where $f(x, U, L)$ is the transformed indicator, U is the upper bound, L the lower bound, x is the indicator, and e is the parameter that represents how much the effort is appreciated. This transformation has many interesting properties discussed by Kakwani (1993). One of them is to yield a performance index that takes into account the startup level of the indicator and the idea that more effort is needed to achieve further improvements. This performance index is obtained directly by subtracting the transformed indicators for different points in time. For the sake of simplicity, let us initially set e to one. To obtain the Kakwani performance index, we can derive [6] by subtracting the value of an indicator transformed by [5] at two distinct points in time.

$$Q(x_i,x_{i+p},U,L)=\frac{\ln(U-x_i)-\ln(U-x_{i+p})}{\ln(U-L)} \tag{6}$$

Where x_i is the indicator at the first point in time and x_{i+p} is the same indicator at a second point, p periods away from the first point. For instance, if our period unit is years, and the first year was 1990 and the second point was 1996, p would be six years. The performance indicator has a property that is very useful, that of being additively decomposable. In other words, if we want to compare, for instance, a country for which the points are eight years apart, and another for which the points are four years apart, we just have to divide the performance index [6] by the p number of periods between x_i and x_{i+p} to get the average annual performance [7].

$$Q(x_i,x_{i+p},U,L,p)=\left(\frac{\ln(U-x_i)-\ln(U-x_{i+p})}{\ln(U-L)}\right)\left(\frac{1}{p}\right) \tag{7}$$

Going back to our hypothetical example, calculating the performance index for groups A, B and C would result, respectively, in the following performance indexes: 0.13, 0.15, 0.20 (supposing the changes were one period apart and $e = 1$). So the performances were rated taking into account the departure level, and, in our example, the rank is reversed in relation to the rank we would obtain, for instance, if we used the slope of a linear or logarithmic trend as a performance index.

Although the spreadsheet application does not offer the facility of plotting a trend curve defined by the performance index and the achievement function, this is not hard at all to implement. First step is to transform the indicator at the two available points in time using the achievement function [5]. On second step we calculate the performance by period, in our case the annual performance, using [7]. Then we predict the value of the achievement function for a point distant *t* periods in time from x_i taking advantage of the fact that the performance index is additive.[8]

$$f(\hat{x}_{i+t},U,L) = f(x_i,U,L) + Q(x_i,x_{i+p},U,L,p)\cdot t \qquad [8]$$

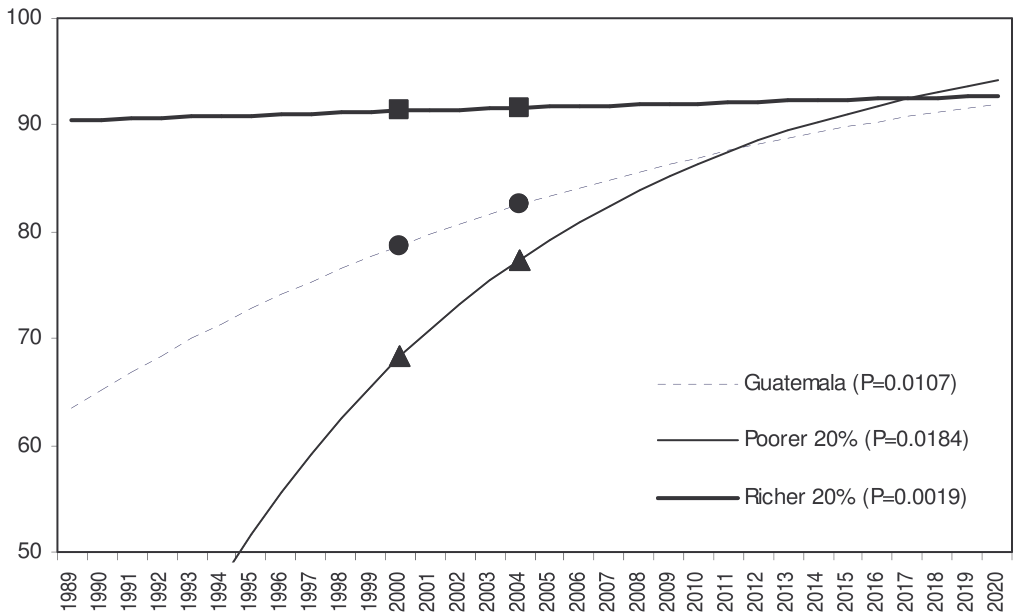
Once we calculate [8] for as many points as we want, we just have to transform them back to the original unit by applying[9] [9], thus obtaining the predicted values for the indicator at those points.

$$\hat{x}_{i+t} = U - (U-L)^{1-f(\hat{x}_{i+t},U,L)} \qquad [9]$$

On Chart 10 below, we deployed the same data used on Chart 8 to fit an "achievement trend" with values predicted using [8] and [9].

CHART 10

Net Attendance Ratio in Primary Education, National, Bottom and top Quintiles—Observed Points and Achievement Trends. Guatemala

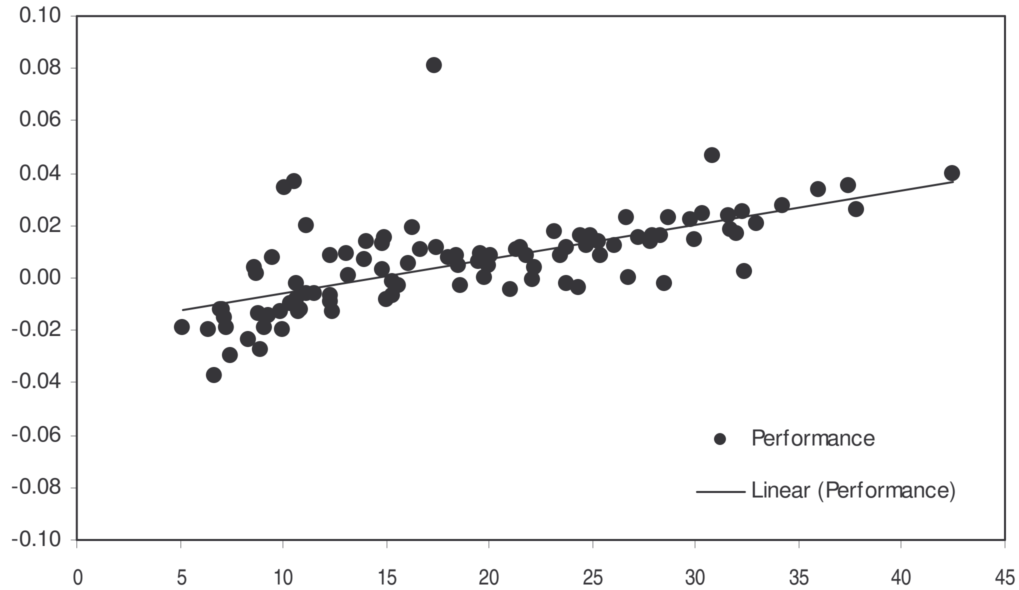


Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

Although the result is slightly better than the one we got fromn Chart 8, the trend curves are still crossing. The problem, once more, is that we are assuming constant performance. And even using the achievement function with the effort appreciation parameter set to unity, the performance of Guatemala in improving the net attendance ratio of its poorer population was indeed higher than the national average. But it is unlikely, because of the issues already discussed, that this good performance will keep constant as the net attendance ratio of the poor improves. In Chart 11 we used the same set of data we deployed for Chart 9, but instead calculated the annual performance index [7] for each of the 97 population groups of Guatemala. We can verify that the performance index decreases as the departure level of the indicator becomes closer to the logical upper bound, even if we judge improvements in this range as being a result of more effort.

CHART 11

Variation of the Kakwani Performance Index. Guatemala



Source: Author's calculations based on data from the Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

By using Kakwani's achievement function we solved the problem of imposing a lower and an upper bound to our projections, and we got only one parameter (besides the observed indicator) that really defines the shape and the position of each trend curve (the performance index). Hence, the task of incorporating decreasing performance in our projections became easier. We just have to substitute the constant performance by period using an estimated variable performance, which values are predicted by the regression line shown in Chart 11. Actually, we won't use the regression line shown in Chart 11. Instead we will use the one represented by equation [10], fit just for the set of *g* groups that had a positive performance, for we deem negative performances when the indicator is close to the upper bound as being a result of sample errors or changes in the design of the surveys that were used as primary data sources. Otherwise, the projected net attendance ratios would decrease after reaching a certain level below the logical upper bound.

$$\hat{Q} = f(U - x_{gi}) = a(U - x_{gi}) + b \quad \text{if} \quad x_{g(i+p)} - x_{gi} > 0 \qquad [10]$$

Our assumption of decreasing performance will then be based on the empirical observation of how performance, on average, decreased for many groups of a particular country as their indicator approached its logical upper bound. Before proceeding, however, there is an additional consideration to be made about equation [10]. Even if we consider only groups with positive performances to estimate the parameters of this regression we might get negative performances. This would happen if our estimations yielded a negative *b* constant. Therefore, we must impose some constraint for *b*, and our natural choice is that *b* should be equal to zero. The reason is that *b* is the value of the predicted performance when the indicator reaches its logical upper bound. When this happens, performance must become zero, because there is no more room for further improvements.

Other issue to bear in mind is that under the assumption of decreasing performance represented by equation [10] we should predict the level of the indicator only for the unobserved points *after* our last available point in time. And this should be done period by period, so that each predicted value closer to the upper bound is used to predict the value of the next point. For periods before the two initial points in time, and between any pair of points in time for which we have the value of the indicator, we plot the trend assuming constant performance by period using [8], assuring that at our last point, x_{i+p}, the predicted value of the achievement trend will be the same as the observed value. Otherwise, the predicted values would differ from observed values. Considering all these issues, we arrive at [11].

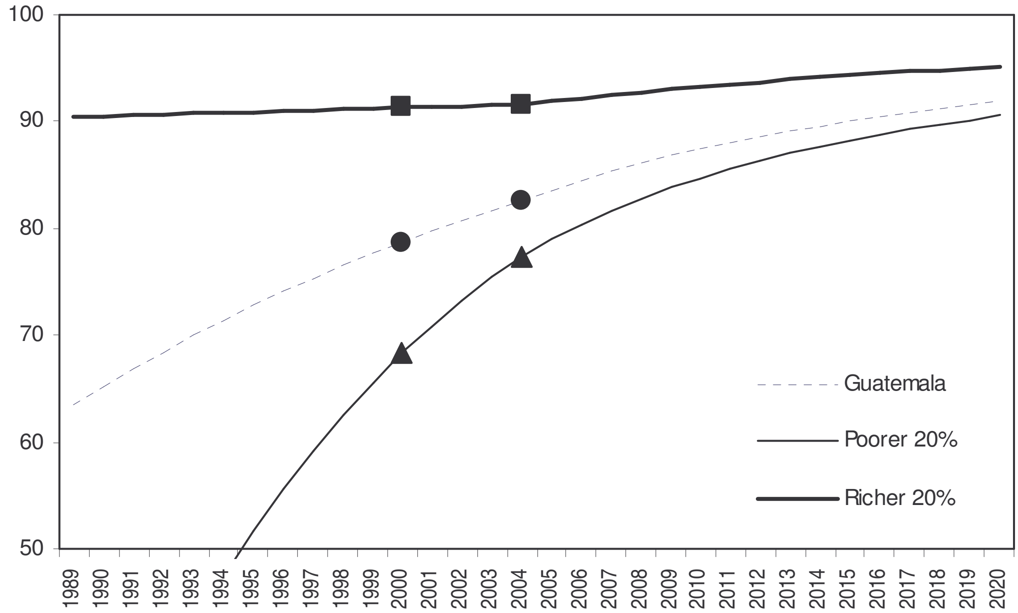
$$f(\hat{x}_{i+t+1}, U, L) = f(\hat{x}_{i+t}, U, L) + a(U - \hat{x}_{i+t}) \quad \text{if} \quad t \geq p \qquad [11]$$

Where *a* is the slope of the linear regression [10] estimated by ordinary least squares with the intercept *b* set to zero. By applying [11] period by period, performance will decrease as the predicted level of the indicator increases, and we will solve the problem of crossing trend curves. After we get the predicted values of the achievement functions for all desired periods after the available observation points using [11], and between these points using [8], we transform all predicted values back to the indicator's original unit using [9]. Then we are able to represent the "achievement trend". The result of this exercise can be seen from Chart 12.

The projection represented in Chart 12 is indisputably better than our previous tries (Charts 8 and 10). First advantage is that we do not have those crossing curves that were unreasonable given our intuitive knowledge of how inequality works—now we have a rank preserving projection. There are other interesting features as well. One of them is that as the indicator of the poorer group improves, it approaches the national average. The second interesting feature is that the projection tells us that there is room for improvement of this indicator even for the richer 20%, and that the national level of the net attendance ratio tends to be below that of this group yet for a long time. This aspect of the projection technique requires some clarification.

CHART 12

Net Attendance Ratio in Primary Education, National, Bottom and top Quintiles—Observed Points and Achievement Trends with Decreasing Performance after the last Observed Point. Guatemala



Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

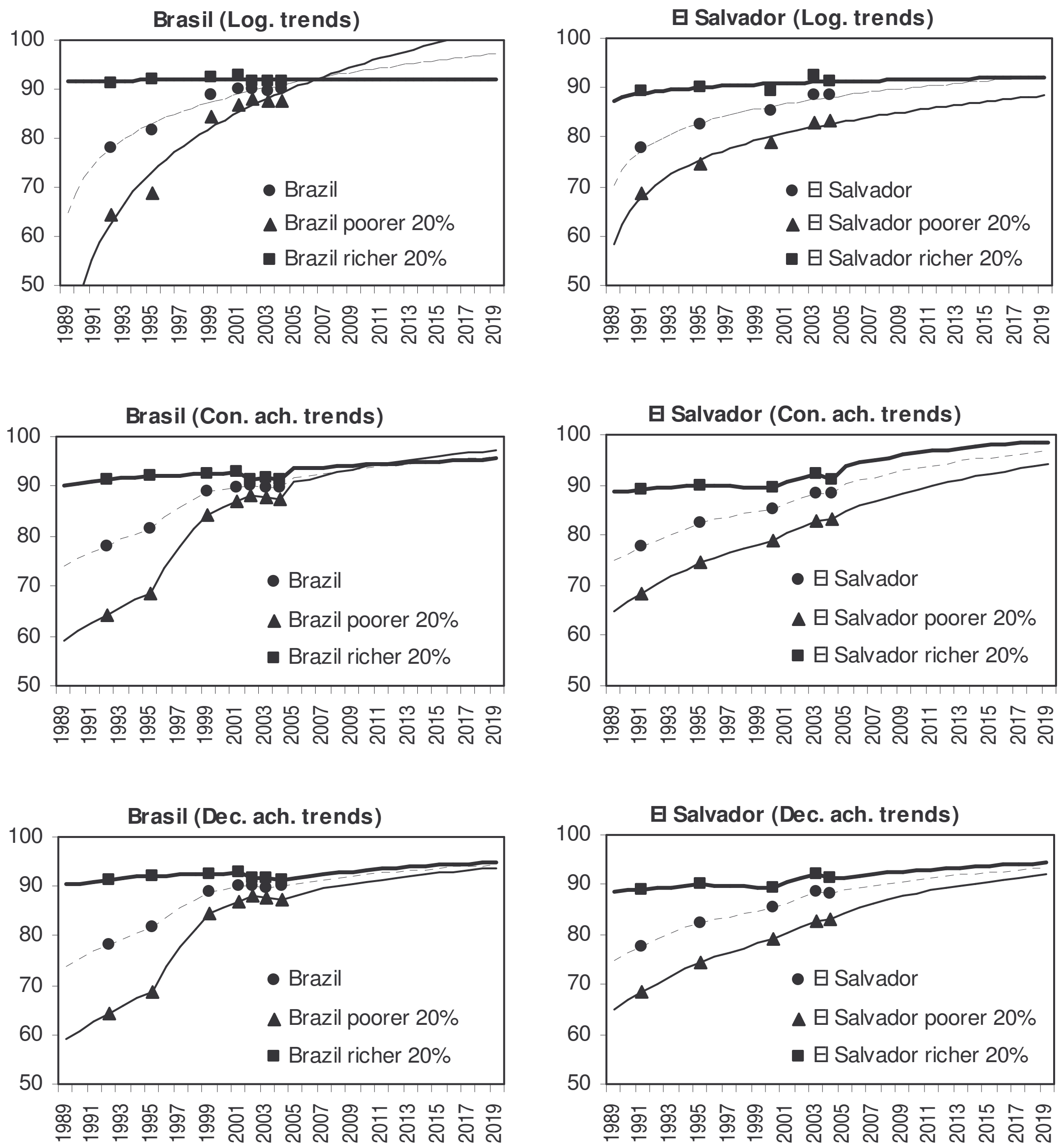
The shape of the achievement trend of the richer group shows an increasing level instead of the stable one we previously obtained. However, this should not be interpreted as though inequality in net attendance in Guatemala is increasing This happens because some population groups of Guatemala that already had a high level of net attendance in 2000 succeeded in having a performance even better than that of the national top quintile. Although the net attendance of the richer group is predicted to increase at a faster pace than between 2000 e 2004, we can see that all trends are in fact converging.

The parameter of decreasing performance obtained from equation [10] is an average of how the performance of 97 distinct population groups decreases, as their net attendance ratios approach the upper bound. From 2000 to 2004, the inequality between the net attendance ratios of these groups went down. And for some groups that were lagging behind, the performance was really very high. For instance, while the national top income quintile had a meager performance, going from a net attendance of 91.3% to 91.6%, females of the top quintile had their ratio going from 88.8% to 92.2%; in urban areas, females of the top quintile went from 82.6% to 96.1%. And there were other remarkable performances as well, such as that of the group of indigenous people in rural areas whose income located them in the 2nd quintile, which went from a net attendance of 69.2% to 86.9%; and that of the poorest females in rural areas, whose indicator increased from 57.5% to 79.6%. This pushed up the average performance close to the upper bound and is the cause of the prediction of increased pace of growth for the richer group.

Before moving on, however, let's apply the projection techniques we have been discussing to two other examples, that of Brazil and El Salvador, countries that are similar from the standpoint of the levels and the evolution of the net attendance ratio, as well as in its availability for many points in time and many population groups.

CHART 13

Net Attendance Ratio in Primary Education: National, Bottom and top Quintiles. Brazil and El Salvador



Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

As we see in Chart 13, at the first point, 1992 for Brazil and 1991 for El Salvador, there was a great distance between the richer and the poorer groups in both countries. Along the nineties, however, while the level of the top quintile remained relatively stable, the level of the net attendance of the poorer group increased considerably, but in a more remarkable way in Brazil. By 2004, the top and the bottom quintiles were closer in Brazil than in El Salvador.

This distinct dynamics of the indicator in the two countries affects the trends we use to predict its evolution. The logarithmic trend (top panel of Chart 13) yields crossing curves for Brazil and if we were to use it we would come to the conclusion that the poorer and the average Brazilians would have a net attendance higher than that of the rich by 2007. But in El Salvador, where the improvement of the indicator for the poorer group has not been so sharp, national average would converge to the ratio of the rich, while the indicator of the poor would be kept at a lower level.

The mid panel of Chart 13 shows us the result of plotting an achievement trend under the assumption of constant performance, using equations [8] and [9]. For the periods before the first observation, and between the first and the second, we use the performance by period of this time interval to predict the values. Then, for each subsequent pair of observations, we use the performance by period between them to predict the values of the indicator for the unobserved points. After the last point, we predicted the values using the performance by period calculated based on the last pair of observations between which all groups had positive performance: 1999 and 2001 for Brazil; 2000 and 2003 for El Salvador. In the case of the latter, the results are already reasonable. But for Brazil, as the performance of the country in equalizing the net attendance ratio of the bottom quintile, raising it towards the national average, was very good, the achievement trend with constant performance still results in crossing curves, albeit a little later than what was predicted by the logarithmic trend, by 2011.

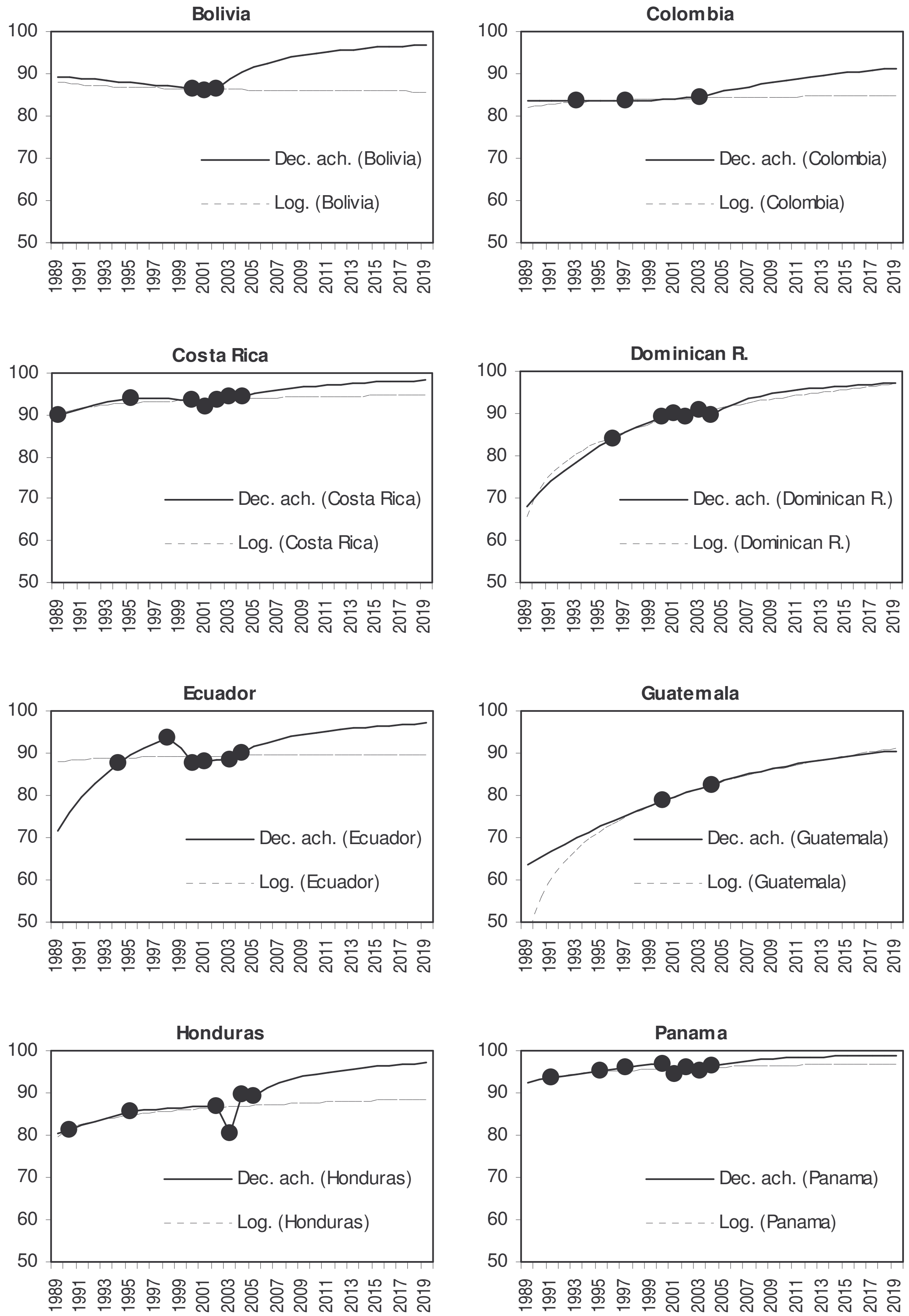
At last, the bottom panel of Chart 13 represents the achievement trend with decreasing performance after the last observed point. To obtain those trends we proceed as described above, assuming constant performance by period and using equations [8] and [9] to predict the values of the indicator before the first observation and between all pairs of observations. Then we run the linear regression [10] for 581 two-year transitions of many population groups of Brazil, and for 376 transitions of El Salvador, to obtain, for each country, the parameter that specifies decreasing performance. Finally, we predicted the values after the last observed point using [11] and [9].

The trends yielded under the assumption of decreasing performance are, we believe, far more reasonable than the others, particularly if we consider the observed evolution, that is, up to the point where we start our predictions. Brazil clearly had a trajectory of convergence, and that is what we obtained from the decreasing performance achievement trend—with the advantage of eliminating those unreasonable crossing curves. For El Salvador, we also got converging trends, but convergence, as our prediction tells us, will happen at a slower pace compared to Brazil—a reasonable result under the light of the fact that the poorer groups of El Salvador did not fare as well as their Brazilian equivalent. It is also interesting to note that the overall performance is not regarded as being good as it was under the assumption of constant performance. For obvious reasons, the assumption of decreasing performance results in more conservative projections.

However, the projections obtained with achievement trends under the assumption of decreasing performance will not necessarily be more conservative than those obtained with logarithmic trends. Depending on the magnitude of the difference between the level of the indicator at the observed points in time, and on the average performance of the population groups as a function of their distance to the upper bound in one or more periods, the projection yielded by the achievement trend can be far more optimistic than logarithmic trends. To illustrate this, we reproduced Chart 6 on Chart 14, excluding the linear trends and adding the achievement trends under the assumption of decreasing performance, calculated in the same way we did for the bottom panel of Chart 13.

CHART 14

Net Attendance Ratio in Primary Education—Observed Points, Logarithmic and Achievement Trends. Selected Latin American Countries



Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.org/xindicators).

We can arrange the countries represented in Chart 14 in two distinct groups. First one would be comprised by the Dominican Republic and by Guatemala. For these countries there is almost no difference between the logarithmic and the achievement trend after the last observed point. However, the imposition of a lower bound by the achievement trends makes them differ from the logarithmic trends in the unobserved past points, particularly in the case of Guatemala. But for our purposes, both trends would yield reasonable predictions.

Second group represented in Chart 14 is made of all the other countries, for which the logarithmic trends predict stability of the net attendance ratio range, namely Bolivia, Colombia, Costa Rica, Ecuador, Honduras and Panama. For these countries, the achievement trend (with decreasing performance) results in predictions far more optimistic than those obtained from the logarithmic trends. This happens, on the one hand, because in these countries, many population groups that departed from low levels of net attendance in primary education have experienced sharp improvements of this indicator. On the other hand, the groups which were already at levels higher than the national average have not improved any further—and in many cases, as they are stuck in what seems to be an empirical upper bound, their indicator is floating up and down due to sampling errors, making their performance negative or very close to zero. As groups with negative performance are not taken into account for the regression in equation [10] (that gives us the estimated decreasing performance as the indicator approaches its logical upper bound), our projection is biased by the groups with positive performance.

Although somewhat odd, this is an interesting feature of this projection technique because it gives us additional information. If we take the Bolivian case as an example, the dissociation of the achievement and the log trends tells us that the worst off groups in Bolivia, regarding net attendance, have gone through significant improvements whilst the better off groups have not, leading us to conclude that inequality in this indicator has decreased very fast. We can see the same happens in Costa Rica and Panama, but as for these countries inequality in the net attendance ratio was already small, the difference between the logarithmic and the achievement trend is not as sharp as in Bolivia. If one bears in mind these characteristics, in order not to incur any misinterpretations, the projection technique using achievement trends can, therefore, be used to project national indicators as well.

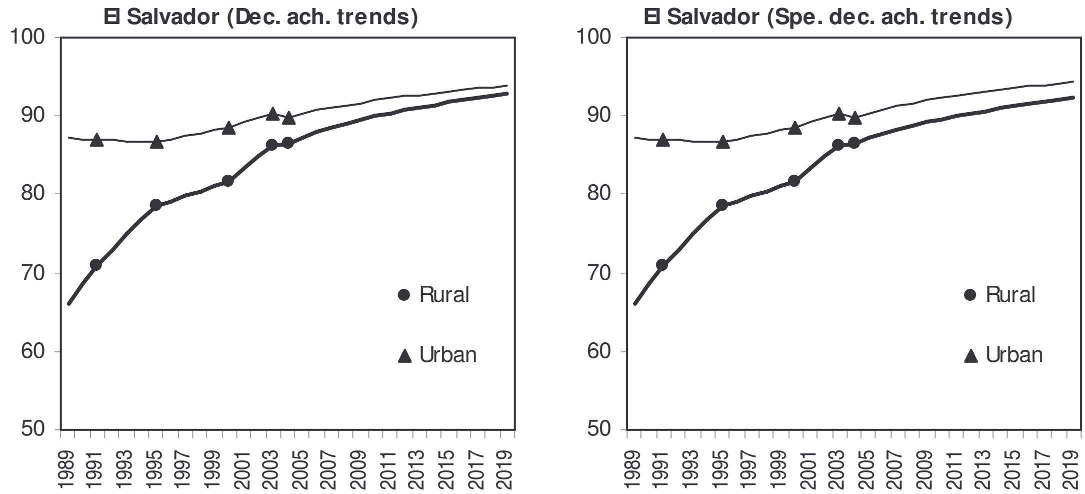
Returning to the problem of projecting disaggregated indicators, up till now we used as examples only groups defined by income. Let’s then examine two other applications for the technique we developed, this time making projections for groups defined by area—whether urban or rural—and by race. We will not give an application for gender because, in the Latin American countries which we took as examples, there are few differences between the net attendance ratios of boys and girls in primary education.

While we were dealing with the net attendance ratio disaggregated by income groups, we assumed that as this indicator improved, it would be hard to maintain performance at its previous level. To know how performance would decrease as the level of the indicator approached its logical upper bound, we gathered a set of two-period transitions for many population groups and periods, calculated the performance in each transition, selected the positive performances, and made a regression using equation [10] considering that the performances were explained by the distance of the departure level from the upper bound. By doing that we got a parameter to represent the average decrease in performance of the whole country.

However, if we want to project the indicator for rural and urban areas, we may want to assume that performance is different and that it will decrease differently in each area type. Therefore, we need to estimate how performance decreases in each area, something that can be easily accomplished by fitting two regressions, one for the set of two-period transitions of rural groups, and other for the urban groups. We did this for El Salvador, fitting regression [10] for 58 transitions of urban groups and for 76 transitions of rural groups—and the results were indeed distinct: the slope for the rural areas is 0.0008, and for the urban areas, 0.0011. This means that performance will decrease slightly faster in rural areas. Nevertheless, the net attendance ratios of both areas will slowly converge as they are already very close to the upper bound. This can be seen on the right panel of Chart 15. On the left panel, we did the projection with the national average decreasing performance which we used in Chart 13. It is easy to verify that we would conclude that convergence would happen faster if we had not calculated a parameter to predict performance for each area.

CHART 15

Net Attendance Ratio in Primary Education, Urban and Rural Areas—Observed Points and Achievement Trends, General and Specific. El Salvador

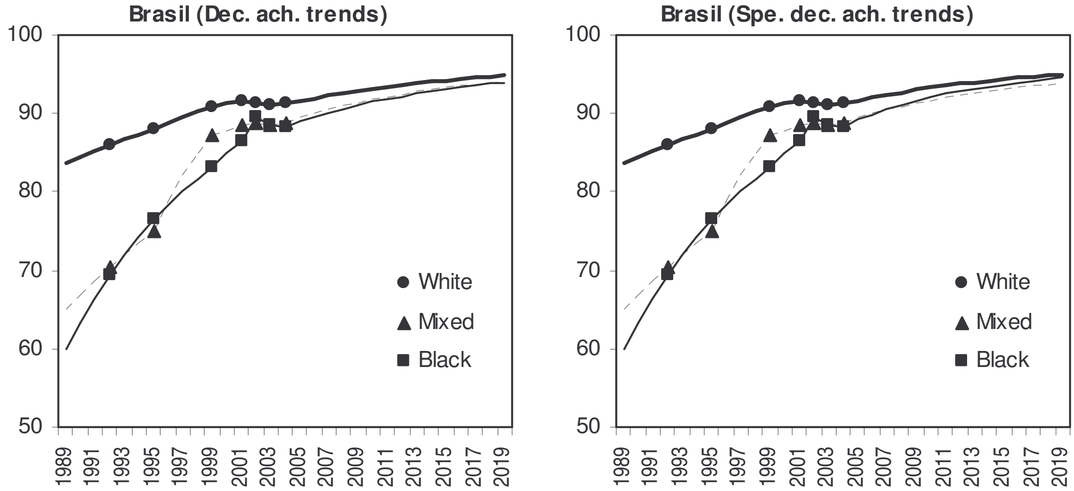


Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

Other situations which we might be interested in estimating different parameters of decreasing performance are when projecting indicators disaggregated by racial groups. We did this for Brazil, where around 99% of the population classifies itself in one of three racial groups: white (branco), black (preto), and brown/mixed (pardo). We had 85 transitions of white groups, 87 of black groups, and 92 of brown/mixed groups. Fitting equation [10] to these transitions we obtained the following slopes: white, 0.0012; black, 0.0014; brown/mixed, 0.0011. Therefore, the black group is the one for which performance will decrease less as the upper bound is approached. As the observed net attendance of this group has always been at levels considerably lower than those of the white group, its indicator will converge to that of the whites without surpassing it in the short run. However, as the differences between the slopes are rather small, the brown/mixed group will also have its indicator converging to the level of the white group, although at a slower pace—even if in the short run it will be surpassed by the black group. We can see this all in the right panel of Chart 16, where the thin dotted line is the trend of the brown/mixed group. In the left panel, we see the projection made with a single national parameter for decreasing performance. If we had used the national parameter, it would not make significant differences for the mixed and the white groups; only for the black group that instead of converging faster to the level of the white would stay a little below the level of the brown/mixed group.

CHART 16

Net Attendance Ratio in Primary Education, White, Black and Mixed Racial Groups—Observed Points and Achievement Trends, General and Specific. Brazil



Source: Inter-American Development Bank, Equity and Social Indicators—EQxIS (www.iadb.or/xindicators).

5 CONCLUDING REMARKS

In this paper we discussed and developed some alternatives to make projections of the MDG indicators in contexts of scarcity of data and/or of technical skills. These projections are not able to give us the definite answer on whether some country will reach the targets by 2015, but they are important because they allow us to make assumptions about countries being on or off track.

We were aware from the beginning that realistic projections are far more complicated than the simple projecting exercises we have shown throughout the paper. Taking, for instance, the net attendance ratio indicator which served as our example, good projections would have to consider the supply and demand sides of primary schooling incorporating variables such as the characteristics of the existent schooling system (are there classrooms for all, how much the government and the families have been expending on education?), and the demographic dynamics (is the number of children in primary school age growing or diminishing, and at what pace?). But the indicator itself, although does not tell us the whole story, indicates—what they are made for—by its level, the state of things produced by the interactions of the many factors that lead children from a given age to attend primary school. Thinking this way, our assumptions, although based only in indicators and in simple techniques, are legitimate. We just have to be always careful not to forget that the predictions we obtain by projecting indicators are just assumptions.

Our main aim was to show that particularly for indicators for which the departure level was very low, and that have gone through significant improvements—but that could be further raised—the linear projections that have been widely used in projecting exercises can lead to excessively optimistic assumptions about the likelihood of reaching the targets. And when we are planning the future, we cannot rely on optimistic assumptions—they might lead to a demobilization of resources, for why should we care about something that is evolving well? When it comes to projecting disaggregated indicators, linear projections in most of the cases would simply yield unreasonable results.

The first alternative we evaluated was to use logarithmic instead of linear trends to project the indicators. We have seen that in those situations in which the indicator was stable, there was no advantage in using a logarithmic trend, for it would yield results similar to those obtained with the linear projection. However, when this was not the case, the logarithmic projections resulted in more conservative predictions of the future behavior of the indicator. We have discussed that the concave functional form of the logarithmic projection is more reasonable in the face of the conventional wisdom that when a positive indicator reaches a high level it is harder to keep improving it at the same rate as in the past. We have also seen that a power function, under certain conditions, would also seem to attend the axiom of decreasing performance. But as a power trend would give results almost undistinguishable from those obtained with logarithmic trends, we stick to the latter throughout the paper.

Then we addressed the problem of projecting disaggregated indicators, starting with indicators calculated for different income groups. We verified that in most situations the logarithmic trends, which yielded fairly good results when projecting national indicators, could lead to conclusions that are not in accordance with our perceptions and knowledge of how inequality works. In situations where the better off group has its indicator already stable at a high level, and the worst off group had its indicator improving significantly after departing from very low levels, though not reaching the level of the better off group, projecting with logarithmic trends would lead us to the conclusion that the poorer groups would soon surpass the richer groups—something that we know will not happen in the real world, unless some revolution takes place.

Analyzing the problem, we discovered that it lay in the fact that even using a concave functional form such as the logarithmic function, we were still supposing that performance would be constant, and therefore we were not thoroughly incorporating the axiom of decreasing performance in our projections. Add to that the problem that by using the plain logarithmic function we were not restricting the predicted values to a certain range of values, and therefore our projections could predict values above/below the logical upper/lower bound that all well behaved indicators have.

The problem of the imposition of a lower and an upper bound to the values predicted by our projections was solved by the use of the Kakwani achievement function. By using this function, we were able to create what we called an achievement trend. The achievement trend is concave as the logarithmic trend, and in some cases will yield almost the same results, but it has an advantage: it does not predict values out of the logical range of the indicator, for its calculation takes its boundaries into account. The other advantage is that from the achievement functions of an indicator at different points in time we can calculate a performance index that respects the axiom of decreasing performance—that will give more weight to improvements made when the departure level is high.

But after making some projections using the Kakwani achievement function and the performance index derived from it, we found out that although we got results better than those obtained deploying the logarithmic trends, the problem that puzzled us had not been solved at all. The achievements trends obtained were still being carried out with constant performance, and would be severely affected by our choice of points in time between which the performance index was measured. Depending on that choice, the achievement trend could be very similar or very distinct from its equivalent logarithmic trend.

Facing that problem we sought for a way of incorporating decreasing performance in our achievement trends. The *ad hoc* solution developed was to calculate the performance index by period for many two-points in time transitions, for as many population groups for which the indicator was available. In other words, if we had the indicator available for three distinct years, and for two population groups, we would have four transitions for which Kakwani's performance index could be calculated. After obtaining those performances, we consider them dependent on the distance of the departure level of the indicator from its logical upper bound, and fit a linear regression constraining the intercept to zero. By doing so, the slope of the fitted line represents how, in a given country, on average, performance decreases as transitions start closer and closer to the upper bound of the indicator.

Applying this technique to our indicator disaggregated by income lead us to very reasonable projections in which the income groups kept their original ranking—a feature in accordance with conventional wisdom about how inequality works. Then we extended the technique to other situations, in which we might want to predict performance decreasing differently for some groups, such as racial groups, and population groups defined by the type of area where they reside.

We also thought of applying the achievement trends with decreasing performance to the national indicators for which we had initially used logarithmic trends. We found out that for some cases this could be a good alternative as well. However, for countries that have gone through fast equalization of groups that were lagging far behind the national average, the projections could be less conservative than those obtained with the logarithmic trends. Nevertheless, they would bring this additional information about the performance for different population groups, that otherwise would be hidden.

An open question is how to choose among all these alternatives? There is not a straightforward answer to this question: the choice will depend on the availability of the indicators, and on other factors, such as how optimistic or conservative one is about the future developments of the socioeconomic characteristic represented by the indicator. Nevertheless, we schematized below our recommended choices considering the availability of the indicator to be projected.

Finally, it is worthy of mention that the techniques herewith discussed and developed can be applied to all sort of indicators, not only those used for monitoring the MDGs. This is rather obvious in the case of positive indicators, such as the net attendance ratio in primary education which served as our example. But negative indicators, those that the less the better, such as the illiteracy rate, or the infant mortality rate, can be projected with these techniques as well. It is just a matter of first transforming them in into positive indicators: the illiteracy rate into a literacy rate; the infant mortality rate into an infant survival rate.

Indicator availability	Recommended options
National for one point in time	Avoid projections
National for 2 points in time	a) Logarithmic trend b) Power trend c) Achievement trend with constant performance
National for 3 or more points in time	a) Logarithmic trend b) Power trend c) Achievement trend with constant performance d) Achievement trend with decreasing performance after the last point
Disaggregated for 3 or more points in time and two or more population groups	a) Achievement trend with constant performance b) Achievement trend with decreasing performance after the last point c) Achievement trend with specific decreasing performance after the last point

To conclude, the simple alternatives we presented should not be considered at all if there is plenty of good data available as well as technical expertise to the projections—whenever this is the case, more rigorous approaches to projection are mandatory. As we stated on the beginning, all projection techniques, no matter how good the data and the assumptions deployed, have flaws. The one we developed here, in an *ad* hoc fashion, based on Kakwani's achievement function, is no exception. As we solve some problems, we create some others. The important thing, always, is to have a good understanding of the technique we are using and of its caveats, in order not to misinterpret the results. If we master the techniques, we can not only avoid misinterpretation of the results, but also eventually use its flaws to our advantage.

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NOTES

1. For useful and brief overviews on this issue, see the International Poverty Centre One Pager series, issues 28 and 33, respectively by Vandermoortele (2007) and by Tabatabai (2007)

2. For a more detailed discussion of why projections can not be treated as forecasts, see Haub (1987)

3. Those interested in doing projections with this alternative technique can send an e-mail to tp@undp-povertycentre.org requesting a set of User Defined Worksheet Functions (UDFs) that can be used to implement the "achievement trends" with the Microsoft Excel spreadsheet. The UDFs are available as an Excel Add-in and as a VBA module. Two sample workbooks with data used in this paper will be provided.

4. For an overview of the evolution of this indicator based on this data source, see the International Poverty Centre One Pager series, issue 23, by Zepeda (2006)

5. By choosing the right chart type it is possible to use the series {1, 2, 3, 4…} to fit the trend curve whilst having {1989, 1990, 1991, 1992…} as labels on the x-axis.

6. A spreadsheet will not allow you to fit a logarithmic or power trend if there are zeros among your data points.

7. There were more groups available, but for some small groups, the indicator was not significant in both time points.

8. If $t = 0$ the predicted value equals the achievement function of the indicator at the first point in time. If $t = p$, the predicted value equals the achievement function of the indicator at the second point in time.

9. Equation [9] is the inverse of the achievement function with e set to one [5]. It will bring any indicator transformed with the achievement function [5] back to its original unit, provided that the lower and the upper bounds specified are the same used in the original transformation.

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