Forecasting Primary Education Efficiency

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ABSTRACT

Education is considered one of the main drivers of welfare in society. However, countries in the world follow different paths when creating basic human capabilities, many of them not in the right direction. Linear extrapolation is still widely utilized to predict future behavior based on statistics like the Primary Completion Rate. This paper presents a dynamic model of primary education as a first step to understand the structure and behavior of educational systems and as an alternative way to extrapolate outcomes of this and other relevant key indicators, like the Gross Enrollment Rate. The model is calibrated for the case of Nicaragua.

Keywords: Education efficiency; Input-Output analysis; Simulation; Forecasting.

I. Introduction and review of the literature

Education promotes social change. The causal role of education in supporting higher economic growth rates and more equitable distribution is well known (Barro, 1999; Hanushek and Kimko, 2002; Mankiw et al, 1992; O'Connell and Birdsall 2001; Birdsall and Londoño 1998). Education provides a unique welfare-improving opportunity for countries needing improvements at the societal level.[1] Yet, countries around the world

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[1] Many policy initiatives are consistent with this reasoning. For instance, 189 countries around the world recently signed the Millennium Development Goals or MDG (World Bank, 2003). These goals are summarized in a list of objectives expected to be complied by these countries by 2015. Universal primary

embark on different paths when creating basic human capabilities through education. The United Nations, in its resolution 55/2, the so called Millennium Declaration, has pledged that by 2015 "…children everywhere, boys and girls alike, will be able to complete a full course of primary schooling and that girls and boys will have equal access to all levels of education" (UN, 2000).

This declaration, like others[2], have made clear not only the need for securing primary educational access to all, but also the need to adequately measure and forecast whether countries' efforts will permit attaining this goal. Studies have spawned to this end. They have shown that, countries like Brazil, Nicaragua, Cambodia, South Africa, Guinea, and The Gambia appear to have achieved great progress during the last fifteen years, while others, like Afghanistan, Venezuela, Belize, Zambia, Republic of Congo, Cameroon, Kenya, and Madagascar have lost much ground (Bruns et al, 2003).

While a countries' inability to embark in a path that will allow meeting the goal timely can be attributed to many causes, from flawed policy intents to lack of resources, there is still an important issue regarding the difficulty in forecasting the potential outcomes of efforts to achieve this goal. Education relates to social change through a large and complex collection of variables whose interrelations, feedbacks, and delays make the monitoring and assessment of possible outcomes and impacts nothing short of puzzling.

Thus, although there has been a renewed interest on measuring countries' progress using outcomes rather than concentrating exclusively on access to education and progression through the education system (UNESCO, 2003), many studies still focus exclusively on measures of access and participation, but they understate completion and other measures of achievement. Clearly both, access and completion, do provide very valuable information about the primary education system, and the debate about what the appropriate indicators are for measuring both aspects is still alive.

Many of the difficulties associated to forecasting the effects of policy initiatives on educational outcomes can be traced to the choice of indicators used for monitoring the system. Education modeling has taken different streams. They can roughly be classified according to three different research lines: mathematical dynamic optimization; econometric modeling based on regression analysis; and computer simulation models.

Human capital dynamic optimization models are widespread in economics (Barro and Sala-i-Martin, 2003; Dowrick, 2002; Lucas, 1989). These endogenous growth models derive very interesting insights from policy perspectives. Knowledge transmission and accumulation, a side product of human capital is not subject to diminishing marginal returns giving the chance of influencing growth permanently. Subsidizing education, then, may be a way to promote long-run growth in society. Rarely, however, their conclusions are of value for education authorities, especially in developing countries, mainly because

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education finds a privileged place in this list: it is the second out of six primary goals, only behind poverty and hunger alleviation.

[2] For example the Jomtien Declaration (1990) and its endorsement in Dakar (2000).

they are very restrictive in their assumptions[3] and usefulness. Inherent complexity makes them difficult to digest for policy makers without a solid mathematical background.

Econometric analysis is one of the most applied methodologies. It is based on statistical analyses of historical data providing a suitable description of the behavior of the system in the past, and it is typically specified on an additive linear education production function to identify causality.[4] Many caveats are associated with this methodology since it doesn't show a clear relationship between resources and outcomes (Hanushek 2002, 2004). Harbison and Hanushek (1992), for instance, assessed 96 different studies in developing countries. In their study six input variables, with their estimated coefficients, were selected and classified according to its impact in schooling outcomes (significant and non-significant, positive and negative if significant). It turned out the estimated parameters of these input variables were not statistically significant in half of the studies, and, of those that came out statistically significant, signs were often contradictory, thus making it difficult to draw any useful conclusion. Resource allocation is the result of complex interactions and may not be fully captured by these (correlation) analyses which normally presum additive and generalized effects (Hanushek, 2004). As a result they not always provide insight into the processes that play a causal role, and they are not very suitable to deal with and understand responses of the system to new phenomena.

Moreover, despite that the subject is inherently dynamic, it is common to find that most of the econometric analyses for developing countries are cross-sectional, with input measurement occurring simultaneously. Moreover, they generally use Standard of Living Surveys which very often turn out to be outdated and incomplete (see Hanushek, 2002) and, at the very least, neglect the longitudinal evolution of educational systems.

Another limitation faced by these research efforts is lack of data, which is generally aggregated by regions (Barro and Lee, 1997) or not available (Bruns et al, 2003, p. 40-1; Barro and Lee, 1997). In general, most papers have relied for input variables on the more accessible and easier to compile enrollment and participation rates. Gross enrollment rates measure the number of children attending educational centers regardless of age, as a proportion of the population who, according to official regulations, have an age suitable to attend the primary level. It is a stock variable. This one variable, however, doesn't account by itself for the "production" of the system. Primary completion rate measures a flow of the annual output of an education system (Bruns et al, 2003). It is calculated as the number of graduates from last grade in a given year divided by the number of children in the population who have, according to official regulations, an appropriate age for graduation.

Clearly, both indicators provide valuable information about the primary education system. Although there has been a shift toward emphasizing progress measurement using outcomes rather than concentrating exclusively on access to education, many studies focus exclusively on measures of access and participation but understate completion and other measures of achievement.

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[3] Like the existence of a capital market allowing economic agents to connect their life-time horizon with the present.

[4] This function normally takes the form of $O = f(X, R)$ where **O**, is the dependent variable of student outcomes, **R** is a vector of school resources, and **X** is a vector of other inputs into schooling.

In fact, many discussions gravitate around the quantity of schooling received by children. The efficiency argument would point toward reducing repetition and dropouts in the schooling system, thus making actual completion years for the schooling population as close as possible to the years it would take with regular promotion and no dropping out. The difference is the wastage. The smaller the wastage the greater the flow efficiency is. These very quantitative and tangible arguments make for a concrete politically appealing goal: solid territory for easy to grasp initiatives. As Harbison and Hanushek (1992) indicate:

> The central focus on many education policy debates in developing countries is the quantity of schooling received by students, rather than its quality (learning achievement). The substantive reasons behind such a concentration are clear. In the poorest countries, high proportions of students drop out not only of secondary schools but also of primary schools; and many existing schools are filled with grade repeaters. This emphasis on quantitative aspects of schools is also natural from an analytical viewpoint, because quantity –which is based on simple counts of students -is easily observed and measured. Standard governmental statistics invariably record the years of school received by the population. These statistics combined with aggregate cost information provide a tempting opportunity for some sort of efficiency analysis. We argue, however, that the policy debate on quantitative issues has not been informed very much by relevant evidence (pp. 26).

These authors argue that the discussion is plagued with measurement problems "…so severe that some researchers and policymakers eschew altogether the use of quantity measures of school output." In fact, this discussion would require careful measurement and an understanding of the determinants of wastage[5]. We argue, however, that at a more much fundamental level, the discussion is devoid of a very basic understanding of the relationship among the relevant quantitative descriptors of the system and its efficiency.

A brief look at some studies would confirm this. Many of these studies perform linear extrapolation of observed results to predict future outcomes. For example, after using simple linear extrapolation of UNESCO data collected for the period between 1990 and 2000, Bruns et al. (2003) concluded that a country like Nicaragua will reach a primary completion rate of 96% by 2015[6]. If we perform linear extrapolation of our own data for Nicaragua, we should conclude, similarly, that this country will reach a primary completion rate of 100% by 2013 (figure 2) if all underlying conditions hold. According to Bruns et al. (2003) countries are on track to achieving the millennium goal if a projection of the observed trend results in a completion rate of 95 percent or higher by 2015. We thus, accordingly, would dutifully declare Nicaragua on the right track to accomplish the Millennium Goal.

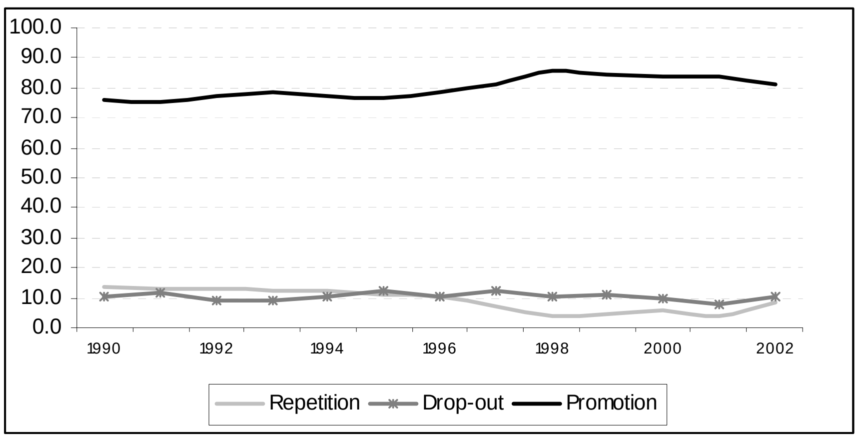
But a careful look at the data would render such comforting conclusion suspect. Historically the basic problem of primary education in many countries like Nicaragua can be roughly summarized as the inefficiency of the system to graduate the students society requires. This inefficiency starts with the inability of the system to cope with the population

[5] Harbison and Hanushek go on to argue for indicators of quality.

[6] For the Nicaraguan example these authors estimate a value of primary completion rate for 1990, another value ten years later, estimate a trend rate and extrapolate to 2015. For Nicaragua these values are 45%, 65%, 2.03, and 96% respectively.

of children in school-age demanding this service due to high demographic expansion. In Nicaragua, for instance, population grew at an average fractional growth rate of 2.87% per year (World Bank, 2003). Transition rates representing alternative ways a student can follow once he is inside the system, i.e., to repeat, to drop-out, and to pass a grade, reflect how delicate the situation is. Repetition and drop-out are especially high in first grades. During 1990 for example, 1 out of 3 Nicaraguan students in the first grade repeated the year and an average of 13.6% of repetition across grades was observed. Similarly 10.6% of students from first to sixth grade dropped out their studies that year. These figures remained fairly stable, close to 9% and 10%, on average, respectively, until 2002 (figure 1).

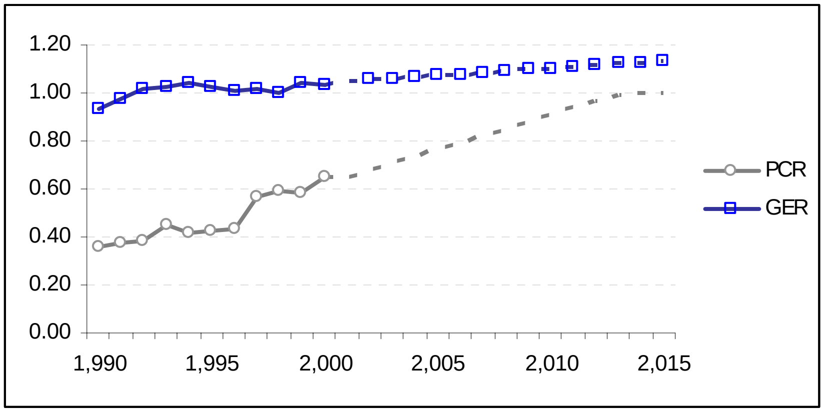
Figure 1. Nicaragua: Average repetition, drop-out, and promotion rates 1990-2002.



Source: Based on MECD data.

Looking at the output side, Nicaragua has made significant advances in its primary completion rate during the 1990s (figure 2) with improvements above 25 percent. It is estimated that in 1990 only 38% of Nicaraguan children completed primary. In 2000 this figure had climbed to 65% and had shown notable progress after 1997. Although the primary completion rate has shown fast growth during this decade, it is difficult to determine ex-ante its long-run behavior, particularly in a situation where many variables are interacting in the system.

Figure 2. Nicaragua: Linear Projection of the Completion and the Enrollment Rate toward MDG.



Source: the authors using data from MECD.

Two questions immediately arise: First, is there a steady-state that can be reached by the gross enrollment rate and the primary completion rate? If so, what is the likely steady-state these indicators would reach in an education system under different combinations of drop-outs and repetition rates? Second, is this long-run level consistent with the target of a Universal Primary Education under the Millennium Development Goals? These questions are not trivial. Changes in educational coverage at the starting age of students, or adjustments in drop-out and repetition rates, could render the (current) gross enrollment and the primary completion rate an inadequate statistic to reflect the likely output of the system for the cohort currently starting school and the ones who will do so in the coming years (Bruns et al, 2002). That is, the system could still be converging to its long-term value, thus simple extrapolations simply would not work. More insight is required.

Most papers claim insufficient data when predicting future outcomes. However given that this restriction cannot be ruled out in the short-run, we consider that a more adequate way to forecast the progress of systems like this is replicating the process as it is observed and then simulating it in time. For example, the by tock of students of an educational system (measured in *people* units), is increased by the flow of new students enrolled every year (*people/year*). This flow of students is a function of the rate of new children coming from the population and reaching an adequate age to start school. Every year, a fraction of children is absorbed by the system and starts formal instruction. Some of these students pass to the next level while others drop-out (*people/year*) and repeat (*people/year*) the school-year. The analysis of these flows is essential to understand the dynamics of schooling. In addition the completion and gross enrollment rates should provide lookout when evaluating their efficiency.

We here propose a model rooted in decision rules which explicitly replicates the physical or “visible” structure (grades and age cohorts) as it is observed in the real system. We suggest that using such modeling approach allows one to simulate systems in a qualitatively realistic way, based on explanatory description of the underlying processes, providing insight in the evolution of the system, and serving as a suitable tool for learning by “simulating”. Such a model would allow to tell apart transient from steady-state behavior.

In what follows we describe the fundamental logic of the model and we use it to explore the Primary Education system in Nicaragua. We limit the study to Primary Education because this is the first step to improve higher stages of the system. Normally it is the one with higher social returns, due to important externalities embedded in it (Arrow, 2002). Quality of education is not explicitly considered in this paper in spite of its striking importance. In addition of the recognized and controversial difficulty to measure quality(Hanushek, 2002); it is evident that in order to produce a product of good quality, we need, first of all, to have one. This is especially true for developing countries.

II. The Model

The logic of the model we present in this section is fairly simple as we are assuming it to be mechanistic. There are 3 state variables: Population (*P*), Potential Population (*L*), and Population in Primary (*G*). Population represents the main input of any Education System. It is represented as a continuous time structure disaggregated into *a* stocks each one representing one-year cohort from 0 to *a* years-old (1). Equation one presents the Population stock which is increased by births (*people/year)* and decreased by death rates (*people/year)*. Aging (*A(t)*)is also included in this equation and represents the transition of a cohort from age *a* to (*a+1*). These flows influence the stock of initial population, $P_a(0)$ **.**

$$P_a(t) = \int_{t=0}^{T} \left[B(t) + A_{a-1}(t) - A_a(t) - D_a(t)\right]dt + P_a(0) \quad \text{where} \qquad (1)$$

$$B(t) = \beta \sum_a P_a \qquad 0< \beta <1 \qquad (1a)$$

$$A(t) = P_a \qquad (1b)$$

$$D_a(t) = \phi P_a \qquad 0< \phi <1 \qquad (1c)$$

Prospective population (*L*) for education is also represented by an array of *a* stocks with similar dynamics as the population sector except that it provides a direct input to first grade through the intake rate ($e_a(t)$). This is shown in the equation (2) where there is an additional outflow represented by those children meeting age requirements to start primary and $L_a(0)$ represents the initial stock of potential population for age *a*. The reason for making a distinction between Population and Potential Population is to keep consistency when comparing people in the education system and people out of the education system.

$$L_1^a(t) = \int_{t=0}^{T} \left[B(t) - e_a(t) - D_a(t)\right]dt + L_a(0) \qquad (2)$$

In addition, equation (3) shows that primary education consists of *i*-grades represented by equal number of stocks from the first to the *i-th* level. In words, $G_{1,a}$(t) represents the population of age-*a* students attending the first grade. We make a distinction between

$G_{1,a}$ (t) and the rest ($G_{i\geq 2,a}$ *(t)*), in equations 3 and 3', because intake $e_a(t)$ only occurs in the first grade and promotion only take place after the second grade. Once children enter the school they may follow three independent directions: passing to the next level ($\pi_{i,a}(t)$) from grade *i* to *i+1* and growing old one year (from *a* to *a+1)*; repeating the year ($r_{i,a}(t)$), which means passing to the next age cohort (from *a* to *a+1*) but remaining in the same grade (*i*); or drop-out the grade *i* at age *a* ($d_{i,a}(t)$).

$$G_{1,a} = \int_{t=0}^{T} [e_{1,a}(t) - d_{1,a}(t) + r_{1,a-1}(t) - \pi_{1,a}(t) - r_{1,a}(t)]dt + G_{1,a}(0) \qquad (3)$$

$$G_{i\geq 2,a} = \int_{t=0}^{T} [\pi_{i-1,a-1}(t) - d_{i\geq 2,a}(t) + r_{i\geq 2,a-1}(t) - \pi_{i,a}(t) - r_{i\geq 2,a}(t)]dt + G_{i\geq 2,a}(0) \qquad (3')$$

All flows are the product of the vector of respective constant fractions (measured in *year^{-1}* units) like intake (α_a), repetition ($\tau_{i,a}$ *)*, drop-out ($\delta_{i,a}$ *)* and promotion[7] ($\rho_i^a \equiv (1-\delta_{i,a}-\tau_{i,a})$) rates, multiplied by the stock of *people* in the respective grade (prospective population in the case of intake, 3a). Values considered "normal"[8] drive these flows and can be modified by authorities.

$$e_a(t) = e\left(L_a(t), \alpha_{1,a}\right) = \alpha_{1,a} L_a(t) \qquad (3a)$$

$$d_{i,a}(t) = d\left(G_{i,a}(t), \delta_{i,a}\right) = \delta_{i,a} G_{i,a}(t) \qquad (3b)$$

$$r_{i,a}(t) = r\left(G_{i,a}(t), \tau_{i,a}\right) = \tau_{i,a} G_{i,a}(t) \qquad (2c)$$

$$\pi_{i,a}(t) = \pi\left(G_{i,a}(t), \rho_{i,a}\right) = \rho_{i,a} G_{i,a}(t) \qquad (3d)$$

$$\alpha_a, \delta_{i,a}, \tau_{i,a}, \rho_{i,a} \in (0,1) \text{ for every } a$$

This formulation (1), (2), and (3) keeps basic conservation rules in this model. For example the number of students flowing into the system cannot be different from the number of students who ever go out. Given that this is a system with non-overlapping sectors, a person cannot belong to two sectors at the same time.

III. Model calibration: Primary Education in Nicaragua

To take a deeper look at the previous example, we calibrated the model for the Nicaraguan case. Data needed for completely characterizing educational systems is seldom available in

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[7] Given that there are only three alternative ways to be followed by children once they are in school, fractional promotion is defined as one minus repetition and drop-out fractional rates.

[8] Normal values are calculated using the fractional rate for the base year.

developing countries. Government's strapped budget makes it difficult to devote resources for statistical data gathering and maintenance purposes. Proof of this is that basic indicators, like the gross enrollment rate and the completion rate are not even considered by the respective ministry. For Nicaragua we were able to construct a more complete set of indicators based on different sources[9]. Table 1 shows fractional values for repetition and drop-out rates for primary education in Nicaragua. Although they are vectors, we assume the same value across ages ($\delta_{i,a}, \tau_{i,a}, \rho_{i,a} = \delta_i, \tau_i, \rho_i$). Table 2 shows vector values for the initial conditions (t=1990) and fractional rates we've utilized to simulate the system until (T=2020). Notice that in this case a = 0,1,2...,16 for population and prospective population; each one representing one-year cohort from 0 to 15 years-old plus the adult's population group (a=16), embodying those who are already 16 years and more. Fractional birth rate (β) only takes non-zero value at newborn age (a = 0) and for simplicity we assume death rate (ϕ) only affects the adult cohort.

Table III-1. Nicaragua: Repetition and drop-out fractions of Primary Education, 1990.

	Variable	Repetition	Drop-out	Unit of measure
Grade (i)	First	0.2951	0.1700	1/year
	Second	0.1391	0.0753	1/year
	Third	0.1009	0.0976	1/year
	Fourth	0.1271	0.1191	1/year
	Fifth	0.0915	0.1085	1/year
	Sixth	0.0800	0.00	1/year

Source: MECD (2001).

Table 2. Nicaragua: Initial Conditions and Fractional Birth, Death, and Intake Rates, 1990.

Age	First	Second	Third	Fourth	Fifth	Sixth	Population Total	Potential Population	FBR[a] β	FDR[b] ϕ	FIR[c] α_a
0	0	0	0	0	0	0	140.000	140.000	0.025	0	0
1	0	0	0	0	0	0	141.353	141.353	0	0	0
2	0	0	0	0	0	0	142.193	142.193	0	0	0
3	0	0	0	0	0	0	131.691	131.691	0	0	0
4	0	0	00	0	0	0	128.058	128.058	0	0	0
5	2.117	0	0	0	0	0	124.406	122.289	0	0	0.02
6	45.150	3.127	0	0	0	0	120.748	72.471	0	0	0.8
7	66.676	25.412	85	0	0	0	117.095	24.922	0	0	0.7
8	46.592	28.733	16.866	2.642	0	0	113.466	18.633	0	0	0.6
9	28.061	25.124	19.822	12.970	1.970	0	109.872	21.925	0	0	0.6
10	15.324	20.674	19.749	16.369	11.337	1.812	106.310	21.045	0	0	0.5
11	8.269	13.683	14.680	14.992	13.552	9.714	102.777	27.887	0	0	0.2
12	5.956	10.515	11.853	13.898	13.234	12.338	99.379	31.585	0	0	0.1
13	2.915	5.369	7.099	9.338	9.335	10.103	96.167	52.008	0	0	0

[9] This quantitative information was drawn from the Ministry of Education, Culture, and Sports (MECD, 2001); Living Standard Measurement Surveys (LSMS 1993, 1998, and 2001) issued by the National Institute of Statistics and Census (INEC); and from the World Bank Development Indicators (World Bank, 2003).

14	1.152	2.372	3.290	5.124	5.503	7.560	93.099	68.098	0	0	0
15	637	1.351	1.845	3.019	3.816	6.954	90.082	72.460	0	0	0
Adu	0	0	0	0	0	0	1.961.269	1.961.269	0	0.02	0

Source: Based on MECD (2001) data and LSMS (1993).
a/ Fractional birth rate, b/ fractional death rate, c/ Fractional intake rate. All measured in $year^{-1}$ units.

Based on this information we used our model to characterize two benchmark scenarios[10]. The first one shows a full intake at the official age (7 years), no-repetition, and no-abandonment. The second one is similar to the first except that under and over-age is allowed. They can be thought as stylized descriptions of any education system and they are simulated for the period 1990-2020.

Figure 4 and 5 show the simulated behavior of these two stylized educational systems. The behavior shown by figure 4 arises from perfect intake at the official starting age plus optimal flow efficiency. Any system working soundly, without any leakage except promotion, will converge to a full Completion Rate (PCR) and a full Gross Enrollment Rate (GER) at 100 percent. Convergence of the PCR to its steady state can be achieved in two ways: either from below (figure 4) or above the maximum level (figure 5). Convergence from below is probably the usual way to reach the optimal level when educational policies are intended to eliminate repetition and drop-out, as well as overage and underage children attendance at every grade.

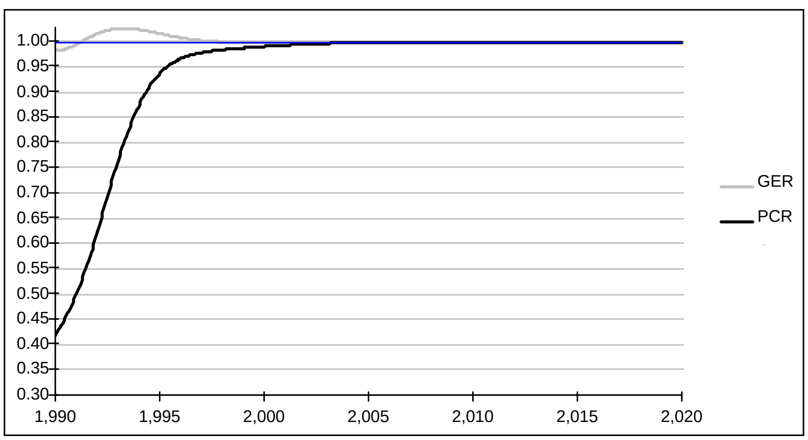


Figure 4. The Completion Rate converges to its maximum from below the Enrollment Rate.

[10] In order to take into account idiosyncrasies, the model described before was slightly modified. In Nicaragua the official age to start school is seven years though the observed range in first grade goes from five to fifteen years. So, in this particular case, $5 \leq a \leq 15$.There is also an inflow that takes into account those abandoning first or second grade and becoming part of the potential population again to restart primary after some years (equation 3). Also, in Nicaragua mothers often decide to send their children back to first grade in cases of early abandonment (first and second grade) to reinforce very basic skills. However when children drop-out from third to sixth grade they usually can write and read and it is considered acceptable (Arcia, 2003). That's why we have included in equation (2) another inflow to account for them $d_{1,2}^{a}(t)$.

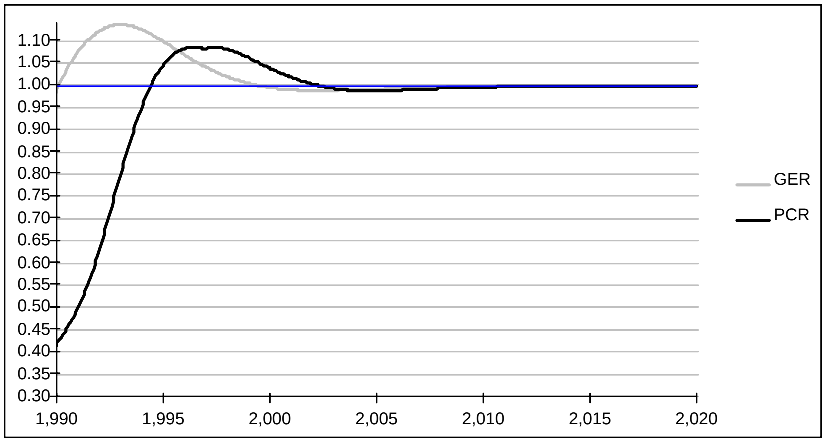


Figure 5. The Completion Rate overshoots its maximum value and converges from above of the Enrollment Rate.

Convergence from above of the maximum level implies that the PCR can eventually exceed 100 percent as well as the GER, when under and overage students are allowed in classrooms. In other words, despite an important percentage of students is enrolled at the official age, there is some fraction of under and overage children attending school. In systems with such characteristics, and also with constant low repetition and low or null drop-out rates, the primary completion rate can surpass its maximum level before reaching its steady state, and there is no guarantee that this steady state will be equal to 1. This situation arises if the initial conditions are defined to start with a perfectly efficient flow of students and wider overage range of pupils already in the system than the one allowed to new entrants. For instance, in figure 5, the fractional intake rate is defined to take non-zero values in children from 5 to 8 years using $\alpha_a = [0,0,0,0,0,0.5,0.8,0.8,0.7,0,0,0,0,0,0,0,0]$ values respectively. However the initial distribution of students enrolled in the system is much wider (5 to 15 years, table 2).

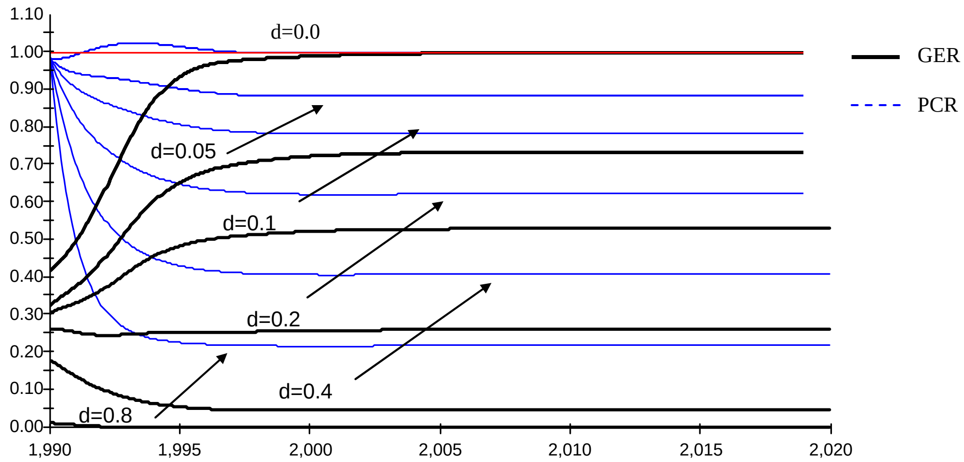
By definition, the primary completion rate incorporates children of all ages finishing the sixth grade divided by the population at official graduation age, twelve years. Starting with a wider age range than the one allowed thereafter reduces the PCR at some point in the simulation; simultaneously those already in the system are directed to finish primary, and, since no drop-out or repetition is allowed, the PCR increases. At certain moment the PCR overcomes the GER until the system gets rid of those overage students initially specified. Nonetheless this is not permanent: after the initial overage students are driven out from the system the PCR goes down rapidly and both variables converge to its steady state which can be slightly over or under one as long as over and under age is not completely ruled out. Only when overage population is precluded in the system the PCR cannot exceed the GER.

Intake (*e*), repetition (*r*), and drop-out (*d*) fractional rates are relevant when analyzing the completion and enrollment rates; however a remaining question is how and how much the former impact these indicators. The first case of the optimal flow efficiency, in figure 4, helps in answering this question.

Different sub-scenarios were chosen to categorize the system. In all of them perfect intake (100 percent of children aged 7) is assumed and the same student population distribution observed in Nicaragua in 1990. In the first simulation drop-out rates are chosen constant across grades and ages at *d*=0%, 5%, 10%, 20%, 40%, and 80 percent, given *r*=0. In the second analysis, it is considered a situation where *d*'s remain constant and equal to zero, while repetition rates (*r*) are increased using *r*=0%, 10%, 20%, 40%, 80%, and 100% (again across grades and ages). Different PCR (thick line) are tagged with the respective *d's* and the associate GER's (dotted line) signaled by the arrows. Two results arise.

When the fractional drop-out rate (*d*) changes, *ceteris paribus*, the GER takes the same direction to the PCR. More abandonment leads to fewer students becoming graduates, no matter what. That means a lower GER and PCR will be reached. Figure 6 illustrates this case.

Figure 6.	Primary school outcomes simulated with different drop-out rates.



When a change in *r* occurs, everything else constant, the PCR and the GER take opposite directions. Some differences with respect to changes in *d* arise. Although the PCR presents similar qualitative behaviors to that showed before, in this case it is evident the relatively less sensitivity of this variable to *r*. Notice for instance the differences in completion rates when *d* and *r* change from zero to 10 percent (figures 6 and 7). For the GER, however, results are completely different; it moves-up (figure 7) instead of moving-down. The reason is straightforward; graduation becomes more difficult for the average student under this scenario, which now will have a long residence time in primary; it will increase the system's inefficiency returning a lower PCR and a higher GER.

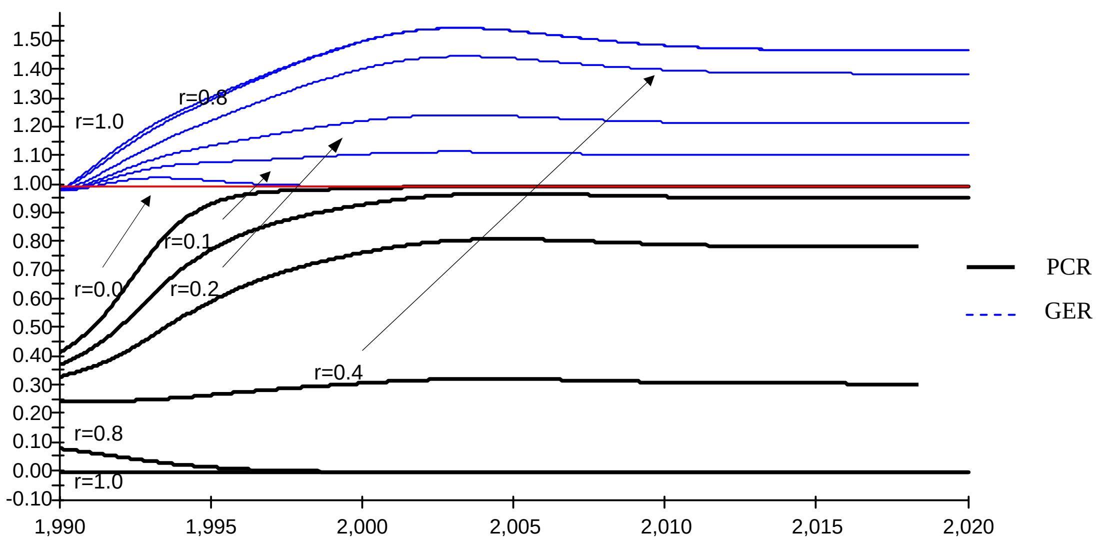
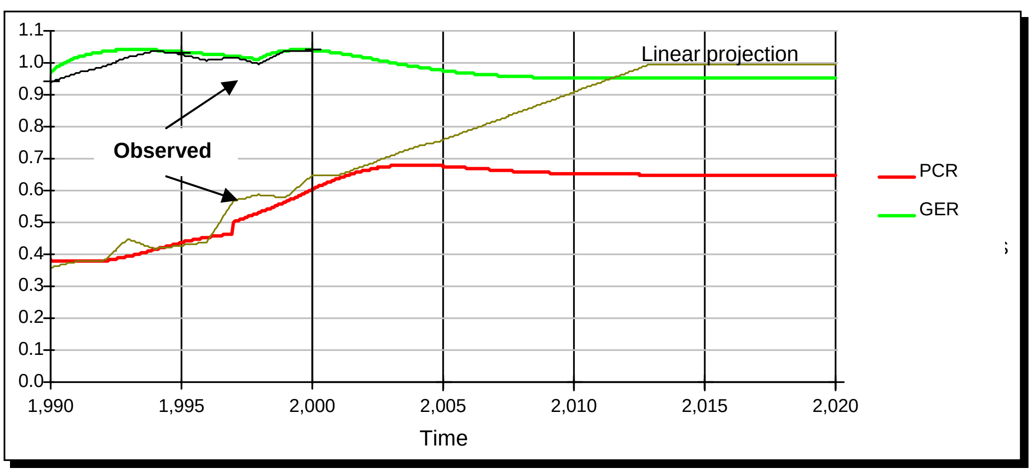


Figure 7.	Primary school outcomes simulated with different repetition rates (*r*).

As a general result, the PCR and GER simulated seem to be very sensitive to fractional drop-out rates. Two implications arise. First, most of the research analysis, in developing countries particularly, implicitly overlooks the importance of school abandonment in education research (Burns et al, 2003 Chap.2; Barro, 1997; Barro and Lee, 2000; Harbison and Hanushek, 1992; UNESCO, 2003)[11] given that drop-out statistics are not easily available. This test shows how fundamental this omission is when predicting future behavior of the system. Second, Figure 6 and 7 show that a single intake rate can be consistent with many different schooling profiles, depending on the values of the fractional repetition and drop-out rates and the state of the system. In other words, the distance among both variables hints about the system's efficiency to graduate students. The long the distance the higher the inefficiency of the system is because the larger are non-desirable outflows avoiding a full promotion of students in the system (measured by the GER). However parents' preferences about children's adequate age of entrance to school force us to relax this point of view.

The model was simulated against the two corresponding time-series in Figure 8. In projecting results, a time horizon from 1990-2020 was selected and the period 1990-2000 was used for calibration. Results confirm Nicaragua has made important advances in the P in 1990-2000. However those results basically come from decreasing repetition instead of decreasing drop-out (see figure 2). An exogenous decrease in the repetition rate of 90% in the observed values and an increase in the intake rate of 25% since 1997 can closely mimic the behavior shown by the completion and the gross enrollment rate for this country.[12] It can be interpreted as most of the important advances observed up to now can be obtained without reducing abandonment. Simulation shows that even after reducing repetition to cero, given current drop-out rates, it is not possible to reach a PCR= 0.7; if no important changes occur soon the system will get to a steady-state around 0.65 and GER = 0.95.

Figure 8. Comparing simulated and observed data.



[11] Enrollment data is normally abundant however repetition, drop-out, and promotion data is rather scarce. See Barro and Lee (2000).

[12] Reduction in repetition rates for this period obeys to an automatic promotion policy implemented by the Ministry of Education between 1997-1999, for grades 1 to 3, and the automatic promotion for all students in zones devastated by hurricane Mitch in 1998. Similarly, the number of students enrolled in primary portrays an important expansion by the end of the 1990's, as a result of authorities' determination to universalize basic education (Arcia, 2003).

IV. Discussion

Bruns et al (2003) define three scenarios to categorize countries according to outcomes (see table 1). A first category encompasses successful countries with a PCR above 70 percent and a GER over 85 percent. A second group includes highly inefficient countries with gross enrollment rates close to successful ones but with completion rates lower than 60%, because of high drop-out and repetition rates. Finally there are low coverage and highly inefficient countries, with both rates below 60 percent. Countries under this category are in high risk of not achieving the MDG.

Table 3. Criteria categorizing an education system

		PCR	
GER		High	Low
	High	Successful (85,70)	Inefficient (80,60)
	Low	Do not apply	Low Coverage (60,60)

Source: The authors based on Bruns et al (2003).

Based on the model developed in the last section, some observations may be drawn with specific considerations for policy makers.

- As this paper shows, the primary completion and the gross enrollment rates provide enough insight when analyzing performance of education systems. Because they encompass main inflows and outflows shaping the stock of students, they asses the input-output condition of the education process. This makes information about the current state of the system accessible and additionally offers an objective metric to appraise the effect of policy decisions. Given that ambiguities could arise when evaluating these statistics for a country, they cannot be analyzed in isolation of the particularities of the system under inquiry. Despite the informative power of the completion and enrollment rate, normally Ministries of Education in developing countries don not take them into account as the relevant variables to look at; and this information is not directly available.

- Very fast improvements can be observed when a country like the one analyzed starts from a very low completion rate level. This however doesn't mean that this fast-growing phase will remain until reaching the maximum level of this indicator. Although a good number of developing countries have achieved dramatic gains in primary completion over the past decade, it becomes clear that without substantial improvements in drop-out and repetition it is impossible to sustain the trend. Several cases have shown history is a poor guide to predict future behavior. That is why linear extrapolation may be spurious to forecast long-run behavior as it doesn't explicitly account on those factors.

- More important than stating that a completion rate growth of 3-4% in a country is required to meet the MDG, is togive guidance about how to get such growth. Education authorities cannot easily translate a simple growth rate target specified in a percent growth rate into specific efforts. What policy makers should know is the level of the completion rate they will get under different intake, drop-out, and repetition rate scenarios and then what the range of action for reaching the desired level is. For example, drop-out rates of at least 0.05 on average across all grades are necessary to reach a safe place in meeting the MDG for Nicaragua (see figure 6). The deadline to start is 2005, given the delays (10 years given current repetition rates) the system presents in reaching a steady-state. If such reduction occurs after this year, or if it is not permanent, a PCR of 0.7 or more is not possible before 2015. On the other hand, if reductions in drop-out are also accompanied by reductions in repetition, the required time to reach a steady-state decreases (5 years) and 2010 is the deadline. The challenge in this case would be reducing repetition without reducing quality. Clearly there are incentives to get to higher completion rates by relaxing promotion requirements and then reducing repetition as well.

- Paradoxically linear extrapolation may work well only when a country has reached a steady-state, but once done, it becomes unnecessary. Otherwise it is deceiving in projecting results. This is especially true when drop-out or repetition rates are absent in data used to built these projections. This research has shown the importance of not omitting any of them when analyzing education systems and also avoiding the use of trend projection when predicting its future behavior.

The model presented here is, to a certain extent, mechanistic. We have not hypothesized about what the drivers of intake, drop-out, and repetition are. Issues related to the effect of household economy, parents literacy, and attractiveness of school are commonly posted as relevant in shaping these flows. They should be considered in a more realistic approach. In a future research we will take a further step in this direction.

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