E C O N O M I C S B U L L E T I N

Enhancing the public provision of education: the economics of education reform in developing countries

Rossana Patron
University of Uruguay

Abstract

The comprehensive evaluation of education reforms in developing countries needs the consideration of the 'triangle' quality-quantity-equity in the short, medium and long term, in a broader context than just the education system itself. There is no simple ‘recipe’ to enhance education, though some general results are found by means of simulation exercises. First, it is expensive and anti-economical to rely on a reform consisting in just more resources, since returns are decreasing. However, focused policies may improve the returns to the expenditure. Second, the timing of the reform matters: policies that are more productive in the short term may be less convenient than competing alternatives in the longer term. Third, effects of the reform are cumulative, and to evaluate it by its generally modest short-term merits may put it at risk of reversion, and/or hinder future investment in the sector

Citation: Patron, Rossana, (2008) "Enhancing the public provision of education: the economics of education reform in developing countries." *Economics Bulletin*, Vol. 9, No. 26 pp. 1-8
Submitted: June 2, 2008. **Accepted:** October 1, 2008.
URL: http://economicsbulletin.vanderbilt.edu/2008/volume9/EB-08I20010A.pdf

1: INTRODUCTION

There are widespread problems in the education systems in many developing countries that hinder delivering the service in an adequate quantity and quality. There are also unresolved equity issues, for example across income groups or gender. Enhancing the education sector requires not only additional resources but also careful planning. In Latin America for instance, Birdsall *et al*. (1998) point out that more than a low level of education spending , the problem is that the sector has failed to use effectively its resources to deliver an equitable provision (reaching all, including the poor). This, they suggest, explains the low and unequal accumulation of human capital in the region. The Paus (2003) study suggests that failure to develop the human capital base has been a major drawback to the development of the region. Nelson (1999) argues that in many middle-income countries, expenditure allocation rather than its level, is the main problem in the education sector. For instance, Birdsall *et al*. (1998) point out that in Latin American countries, the share of higher education in public expenditure tends to be higher (20% on average) than in faster growing East Asian countries (15% on average).

The worrying diagnosis of the education in the region led to several reforms (see for instance, Fischman and Gvirtz, 2001, Nickson, 2001, and Kaufman and Nelson, 2005) aiming to increase coverage, quality and equity in particular at the primary and secondary levels, partially financed by international lenders (World Bank, Inter American Development Bank). Even when the reforms led to an expansion in enrolments in basic education as well as at preschool level there is still a long way to go in terms of equity, quality and efficiency of education systems in the region (IADB, 2003). Many authors have stressed some favourable effects of the reforms (e.g., Valenzuela, 2005, Bogliaccini and Filgueira, 2003, Cerdan and Vermeersch, 2007, among others), however, whether these improvements are a fair return to a significant investment in the sector it has yet to be determined. Moreover, there have not been attempts to estimate the overall benefits of reforms in the long term, in a broader context than the education sector itself. It seems clear that evaluating the return of the reform only by its direct effect on the education system itself would be myopic both for policy makers and international lenders. Indeed, modest initial gains could undermine the political sustainability of the reform leading eventually to its reversion, even if in the long term, the return is higher than for most of the plausible alternative policies. Additionally, partial assessment of the returns of the reform may hinder future investment in the sector.

This paper argues that a comprehensive evaluation of education reform in particular in developing countries needs to consider the 'triangle' quality-quantity-equity of educational policies in the short, medium and long term in a broader context (i.e., the economy) than the education system itself. As the effects of reforms are not straightforward, this paper investigates the long-term repercussions of alternative today's policies by means of simulation exercises. More precisely, it analyses the effects of general and focused policies on the education system and the formation of human resources in different time horizons. It also sheds light on comprehensively assessing any education reform. In particular, this paper argues that focused policies favouring disadvantaged groups can effectively foster endowments' growth. Besides, it supports the idea that the production of skills should be thought of in a long-term horizon, as haste in the production of skills makes the task excessively expensive.

This paper is organised as follows. Section 2 describes the provision of educational services and human capital accumulation. Section 3 describes the design of education policies. Section 4 discusses specific policies based on simulation exercises. Section 5 provides the conclusion. The Appendix includes computational details for the sensitivity analysis and list parameter values.

2: MODELLING THE EDUCATION SECTOR

The education sector is modelled following the commonly adopted approach in the education production function literature, in which inputs (teachers, schools, equipment, etc.) are combined using a given technology to produced embodied knowledge. The paper adds to the theoretical literature on the education production function and human capital accumulation by modelling the presence of inefficiencies and the role of educational policy in tackling them. The measure of the 'inefficiency' of the education activity is the proportion of resources devoted to education that are

not transformed into skills (understanding skills as knowledge incorporated in students, i.e., in those successful).

The model reflects three assumptions. The first one is that resources and students are complementary to produce embodied knowledge (i.e., human resources), the second one is that the degree of complementariness to resources is different for advantaged and disadvantaged students and across grades and levels, and the third one is that dropout and repetition rates are negatively related to embodied knowledge in students at decreasing rates. As there is no agreement in the literature on the contribution of resources to the production of knowledge in education activities (see for instance Hanushek, 1979, 1986, 1998, 2002; Krueger, 2003; Vignoles et al., 2000), there is no agreement with the validity of these assumptions nor with the parameter values, thus in the simulation exercises (section 4) a sensitivity analysis will be carried out to test results for a range of economic setups.

2.1: General settings

A general formulation for education activities, with a grade-level-type specification, is:

$$Q_{ijk} = F_{jk}(K_{ijk}, E_{ijk}) \tag{1}$$

where i represents the grade (first, second, etc.), j the level (primary, secondary, university, i.e., j = P, S, U), and k the student's type (advantaged and disadvantaged, i.e., k = A, D). Q_{ijk} is the output of the education activity (subject to constant returns to scale) using the resources allocated to it (K_{ijk}) and given the number and type of students currently enrolled (E_{ijk}). Q_{ijk} represents the output of the activity, which is not necessarily embodied in students (in the form of knowledge or qualifications) due to 'failures' (repetition and dropouts), thus leading to systemic inefficiencies. Assuming a Cobb Douglas functional form (1) results in:

$$Q_{ijk} = A_{ijk} K_{ijk}^{\alpha_{ijk}} E_{ijk}^{1-\alpha_{ijk}} \qquad 0 < \alpha_{ijk} < 1 \tag{2}$$

where A_{ijk} is a scale parameter and α_{ijk} is the elasticity of educational output with respect to the capital input. From (2), the educational output per student is given by:

$$q_{ijk} = A_{ijk}\, k_{ijk}^{\alpha_{ijk}} \tag{3}$$

where $k_{ijk} = K_{ijk} / E_{ijk}$ is resource intensity per student. For each student, q_{ijk} is the amount of knowledge embodied in him/her due to the successful completion of a grade, which builds his/her human capital. As such, low values of this indicator imply that students only embody a small amount of knowledge, which will also affect their future performance (inside and outside the system, in the latter case as productivities). Following Hanushek (1979), students' acquired knowledge defines 'school quality', therefore the *output per student (q_{ijk}) measures school quality*. The specification used for the production of education implies that as the service provided is assimilated differently by heterogeneous students, school quality differs across student type.

The learning process is cumulative, which is reflected by the accumulation of q_{ijk} during the years of schooling using the indicator:

$$f_{nmk} = \sum_{j=1}^{m} \sum_{i=1}^{n} q_{ijk} \tag{4}$$

where f_{nmk} is the knowledge accumulated per student in group k who has completed up to grade n of level m. The indicator f_{nmk} measures the efficiency units of skills that a student gets during schooling, and equates to the concept of human capital.

The presence of student heterogeneity may impose an efficiency-equity dilemma on policymakers. Applying relatively more resources to the disadvantaged operates towards obtaining similar results across groups; however the point is controversial. On the one hand, the production of knowledge is diminished when resources are diverted from those who assimilate it faster. On the other hand, efficiency is diminished when resources are wasted by applying insufficient amounts to some students (the disadvantaged), so that they are unable to learn (they have to repeat), making the return to those resources equal to zero. On this point, for instance, Birdsall *et al.* (1998) argue that the universal access to primary education in Latin America, has become a 'false entitlement' for the poor as the education they receive is of such a poor quality that it gives little real benefit. With heterogeneous students, equal access to the educational system does not imply equal benefits for all students. So, rather than equal access to education, individuals may, or should be offered equivalent learning opportunities, and this also will be investigated in the simulation exercises.

2.2: Repetition and dropout rates

The usual practice in many developing countries is that students who fail to meet the standard requirements of the course have to repeat the grade. Thus, repetition rates are modelled depending of the amount of knowledge individuals manage to get in a school year, as follows:

$$\gamma_{ijk} = b_{ijk} q_{ijk}^{\ -\rho_{ijk}} \qquad 0 < \rho_{ijk} < 1 \quad , \quad b_{ijk} > 0 \tag{5}$$

where γ_{ijk} is the repetition rate, the parameter b_{ijk} determines the level of repetition for given q_{ijk} and ρ_{ijk} (which measures the responsiveness of the rate to q_{ijk}); also $\partial\gamma_{ijk}/\partial q_{ijk} < 0$ and $\partial^2\gamma_{ijk}/\partial^2 q_{ijk} > 0$, which implies that there are diminishing returns to quality. Considering (3) the formulation of repetition rates in (5) also implies that $\partial\gamma_{ijk}/\partial K_{ijk} < 0$ and $\partial^2\gamma_{ijk}/\partial^2 K_{ijk} > 0$, i.e., rates are decreasing with resources at decreasing marginal rates, implying that it may be prohibitively expensive to reduce repetition rates to zero. Using (3) and (5), the elasticity of repetition rates to increments in resource intensity is given by $\varepsilon_{ijk} = -\rho_{ijk}\ \alpha_{ijk}$.

According to Barnes (1999), students drop out of school if they 'fail to learn', and according Hanushek (2004), 'higher student achievement keeps students in school longer'. Hence, school quality is a major determinant of students' path, and the formulation assumed for exits is $\theta_{ijk} = a_{ijk} q_{ijk}^{\ -\delta_{ijk}}$ (the same considerations for expression (5) apply).

The occurrence of repetition affects the average duration of studies by increasing the opportunity cost for the student, and at the same time affects the efficiency of the service. Both wide coverage at entry level and high completion rates as well as the timely progression to subsequent levels are important to assess the efficiency in the provision of the service. Those who repeat or drop out without completing a course fail to accumulate any knowledge in spite of the resources devoted to that aim, so improving rates of completion in time will improve the efficiency of the service.

The pattern of endowment growth (i.e., the generation of a mix of differently qualified units of labour) is given by the timing of exit from the system. The interactions between the quality of the education system and the quality of the labour force are straightforward, as the human capital embodied by people entering the labour market depends on the years of schooling successfully completed and the quality of education received. Hence, the human capital embodied by newcomers into the labour force varies with any change in the quality and efficiency of the education system. A useful measure of the value of education is the present value of total labour

produced ($PVTL$). It measures the present value of the stream of labour produced by the education system valued by the respective wage (see computation details in the Appendix). It measures the value of the production of endowments of all types of labour, and shows the value to the economy of inputs produced (human resources).

3: EDUCATION POLICIES

In the above model, education is publicly provided, which makes the problems of coverage and retention of the system dependent on the performance of the sector itself. Ideally, the education system would pursue the provision of high quality education with wide coverage, so the production of skills would be maximised. This section analyses the design of educational policies: quantity, quality and equity are policy matters, and the design of education policies dealing with them is discussed. A simple top-down model of allocation of resources is assumed for the whole system, as this procedure may be an adequate representation of the situation in many developing countries. The budget for education activities is exogenously determined; internally, it will be allocated as a two stage process: in the first stage, the central authority distributes resources across levels, and in the second, educational institutions allocate the resources received across students' type. This simple decision making structure dos not consider the provision of incentives to agents (teachers, head of schools), which is relevant given the lack of market incentives, but it is enough to make explicit the effects of education policies in the economy (as shown in section 4).

3.1: Central authority

It is assumed that the central authority tries to maximise systemic efficiency by concentrating in the quantity of successful students in the whole system, while the local education authorities deal with 'quality' of provision across student types. It is assumed that the central authority's utility function takes the following form:

$$U = \prod_j \left[E_j (1-\gamma_j)(1-\theta_j) \right]^{\phi_j}$$

The parameter ϕ_j represents the central authority's preferences, and the central authority can tackle inefficiencies across the system selectively according to its preferences. The higher U , the higher will be the system's internal efficiency. The optimisation programme can be formulated as:

$$\begin{aligned} \underset{K_j}{Max} \quad & U = \prod_j \left[E_j (1-\gamma_j)(1-\theta_j) \right]^{\phi_j} \qquad \sum_j \phi_j = 1 \\ & s.t.\ \overline{K} = \sum_j K_j \\ & \gamma_j = c_j q_j^{-\rho_j} \\ & \theta_j = a_j q_j^{-\delta_j} \\ & \overline{K},\ E_j \ \ given \end{aligned} \tag{7}$$

where $\overline{K}$ is total resources destined to education, and ϕ_j is the weight given by the central authority to each level. According to this programme, the central authority will allocate resources so as to maximise the number of students completing each subsystem by seeking to reduce dropouts rates and repetition rates. There is no close solution to the programme but it can be solved numerically. The optimal allocation ensures that the capital intensity per student is such that the average rates of repetition and dropout are reduced so as the number of students completing each level maximise central authority's utility. The model allows the central authority to affect 'completion in time' rates by changing the allocation of the budget.

3.2: The education authority's policy

Once resources are allocated across levels, the education authorities will seek to optimise the use of these resources by student's type. The education authority's utility depends on the overall quality across groups, as follows:

$$\begin{aligned} &\underset{K_{jk}}{Max} \quad \prod_k \left(q_{jk}\right)^{\mu_k} \\ &s.t.\ K_j = \sum_k K_{jk} \\ &q_{jk} = f\left(k_{jk}\right) \end{aligned} \tag{8}$$

where K_j are resources allocated by the central authority to level j in the first step, and the parameters μ_k represent the educational authority's preferences over education provision across student groups. The allocation resulting from the first order conditions is $K_{jk} = \frac{\alpha_{jk}\mu_{jk}}{\sum_k \alpha_{jk}\mu_{jk}} K_j$.

It is apparent that by appropriately choosing μ_k in program (8), the authorities may consider different approaches in their policies, i.e., egalitarian, elitist, or progressive policies.

4: POLICY OPTIONS: SOME SIMULATION EXERCISES

This section intends to provide criteria to assess more comprehensively any education reform.. Notwithstanding this, the section remains under the partial equilibrium approach. Some alternatives to improve the *productivity of education expenditure* (i.e., the value of efficiency units of labour produced per monetary unit) will be investigated by means of a series of simulation exercises.

Alternative values for α_{ijk} (elasticity of educational output to capital input), ρ_{ijk} (elasticity of repetition rate to quality) and δ_{ijk} (elasticity of dropout rate to quality), the unknown parameters in the assumptions in section 2.1, are tried in the simulation exercises for the sensitivity analysis. The options are: i) for α_{ijk} : low or high responsiveness to resources; similar or dissimilar across student groups, being higher for the disadvantaged*;* ii) for ρ_{ijk} and δ_{ijk} : low or high responsiveness to quality; similar or dissimilar across groups, being higher for the disadvantaged. Two scenarios will be selected for the sensitivity analysis:

Scenario A. ***Moderate elasticities and low heterogeneity:*** similar and moderate elasticities to resources and low responsiveness to quality of repetition and dropout rates for all groups. This will be a scenario where repetition and dropout rates do not improve significantly with quality, and the addition of resources to the education sector does not cause a big impact on quality.

Scenario B. ***High elasticities and high heterogeneity*****:** high elasticity to resources group and high responsiveness to quality of repetition and dropout rates for disadvantaged group. This will be a scenario where repetition and dropout rates improve significantly with quality, and where the addition of resources to the education sector has a large impact on quality for the disadvantaged.

The main findings are as follows:

1) Even modest targets would be very costly...

In this section, the ability of generalist policies to meet certain targets is investigated. Three alternative targets to improve systemic performance are tried: 1) targeting quality (productivity),

2) targeting completion rates and 3) targeting the number of graduates. The results of the simulation exercises are presented in Table 1.

Policy 1 aims at improving 20% average productivity at secondary level (q_S) in the mid term. Table 1 shows that this target would require an increase in the budget between 37.17% to 70.75%, showing that the reform would be more expensive when there is student heterogeneity, as disadvantaged students are costlier to educate.

(Insert Table 1)

The target of policy 2 is to reduce average dropout rates at secondary level in 20% in the mid term. This policy, as the results of the simulation in Table 1 show, would be very expensive, requiring an increment between 1 to 9 times the original budget according to each scenario, depending on how sensitive are dropout rates to resource increases. However, note that the target is very modest, given the prevalence of early dropouts. A reduction of 20% of dropout rates would mean that there still will be a significant proportion of students leaving the system without basic education.

The target of policy 3 is to increase the number of university graduates in 10% in the mid term. Table 1 also shows that a not very ambitious targets would require an increment in resources between 60% to about double of the current budget according to each scenario, depending also on how sensitive the completion rates are to additional resources.

Under this model the effectiveness of increases in the budget to improve students' performance is limited as the responsiveness of repetition and dropout rates to resources is negative but at decreasing rates. Thus the productivity of the expenditure (in terms of labour produced) is decreasing with the size of the budget. These exercises show that even when the specific targets are modest, the size of the resources needed make such reforms almost unrealistic in all scenarios, leading one to conclude that generalist policies are very costly, as higher increases in the budget get lower return.

2) Focused policies may be more efficient...

Not only does the productivity of the expenditure decrease with resources, but also, generalist policies do not address inequality issues. This section investigates the convenience of applying focused rather than generalist policies. Policy 4 consists of allocating more resources to education, but introducing changes in authorities' preference parameter (respect to the quality of the service provided across students´ type). The exercise simulates an increment of the budget of 10% plus a 25% increment in the preference for the disadvantaged. Table 2 shows the results of policy 4 against the generalist policy (10% increase in budget without changing preferences). This table presents the changes of present value of total labour (PVTL) in the short, medium and long term (see description of computation of present value of total labour (PVTL) in the Appendix), for focused over generalist policies.

(Insert Table 2)

The effects differ for alternative set ups. In the long term, in scenario A the productivity of the expenditure deteriorate in relation to a generalist policy, whereas in scenario B the result is better for focused policies. Thus the diversion of resources toward the disadvantaged (focused policy) may be more profitable than a generalist policy in presence of high heterogeneity. Besides, for scenario B (high elasticities and high heterogeneity) policy 4 is worse than a generalist policy (-0.16) in the short run but is better in the long term (0.58%). Thus, the time horizon also becomes relevant in the evaluation of policies, making the selection of policies on short term-merits misleading.

Besides, Table 3 shows that under scenario B policy 4 will also produce an increment for skilled and medium-skilled labour in the long term against the production of low-skilled labour, due to a significant improvement of the performance of the disadvantaged, in a context of high heterogeneity and high elasticities. Then, policies focused to attend with priority inequitable

situations may be an efficient option to promote skill production, and such policies also lead to better results (in economic sense) than a generalist one.

(Insert Table 3)

3) Allocation across levels matters...

An issue frequently discussed in the literature is the government's preference for basic or higher education, which is investigated in this section. Alternative policies are simulated, namely policies 5 and 6. Policy 5 consists of increasing resources to education (10%) while increasing the central authority´s preference for basic education (primary and secondary), policy 6 consists of increasing resources (10%) while increasing preference for higher education.

As Table 4 shows, policy 5 clearly dominates policy 6, as policy 5 improves the productivity of educational expenditure in the long term in the range of 5.12%-5.62%, while policy 6 makes it only in the range 3.97%-4.89% across scenarios. So, enhancing basic education (by allocating proportionately more resources) improves the producitiviy of the expenditure, as it improves systemic internal efficiency.

(Insert Table 4)

As shown in Table 5, in terms of the labour mix produced, policy 6 seems to be an effective policy for producing skilled labour in the short term, as the production of skilled labour can be increased between 1.71% to 2.05% in such a short period. However, the table also shows that policy 5 is a more efficient way to produce skilled labour in the long term for any set-up (as it produces an increment ranging from 2.48% to 3.43% in the long term), even when in the short term it produces a non positive effect on skill production. Then, policy 6 is a short-term policy for producing skilled labour but is costlier, as the productivity of expenditure is lower (see Table 4).

(Insert Table 5)

5: CONCLUSIONS

The paper provides a flexible framework to deal with educational provision and public policies in developing countries, linking the impact of quality-quantity-equity of educational policies on labour markets. It includes the presence of inefficiencies, modelling the role of educational policies on tackling them.

Efficiency, equity and quality in the education system depend on appropriate targeting by government and authorities. The policy discussion above leads us to suggest that more sophisticated educational policies rather than generalist ones may increase the efficiency of the expenditure on education in terms of the quantity-quality of the output delivered to the labour market. There is no simple "recipe" for improving quality and internal and external efficiency in the public education system but some general results are found by means of simulation exercises. First, as the return of the reform is decreasing with the size of budget increases is anti-economical the reliance on a reform consisting in just more resources and even very modest targets to improve the system performance would require -without more sophisticated policies- huge increments in budget with a poor return. In this sense, the paper investigates the capacity of focused policies to improve the productivity of the expenditure, in particular toward basic education and/or the disadvantaged students. Second, the timing of the reform matters: policies that are more productive in the short term may be less convenient than competing alternatives in the longer term, so the actual policy may be influenced by the time horizon chosen by policy makers. Third, effects of the reform are cumulative, and to evaluate the reform by its modest, in general, short-term merits is myopic and may put the reform at risk of reversion or to hinder future investment in the sector. Lastly, the importance of correctly identifying the economic set-ups before estimating the total returns of any education reform, is apparent from the simulation exercises.

REFERENCES

Barnes, D. (1999) Causes of dropping out from the perspective of education theory. In *Schooling for Success. Preventing Repetition and Dropout in Latin American Primary Schools* by Randall, L. and J. Anderson, Eds., M. E. Sharpe, New York, 14-22.

Birdsall, N., Londono J. y O'Connell, L. (1998) "Education in Latin America: Demand and distribution are factors that matter" *Cepal Review* **66**, 39-51.

Bogliaccini, J.A. and F.Filgueira (2003) "Las reformas educativas en Chile y Uruguay: descentralización orientada al mercado vs. centralismo estatista" IPES working paper 1.

Cerdan, P. and C. Vermeersch (2007) "More time is better. An evaluation of the full-time school program in Uruguay" World Bank working paper 4167.

Fischman, G. and S. Gvirtz (2001) "An overview of educational policies in the countries of Latin America during the 1990s" *Journal of Education Policy* **16**, no.6, 499-506.

Hanushek, E. (2004) "Some simple analytics of school quality" NBER working paper 10229.

Hanushek, E. (1979) "Conceptual and empirical issues in the estimation of educational production functions" *Journal of Human Resources* **14**, no 3, 351-388.

Hanushek, E. (1986) "The economics of schooling: production and efficiency in public schools" *Journal of Economic Literature* **24**, 1141-1177.

Hanushek, E. (1998) "Conclusions and controversies about the effectiveness of school resources" FRBNY *Economic Policy Review*, March, 11-27.

Hanushek, E. (2002) "Publicly provided education" NBER working paper 8799.

Inter-American Development Bank (2003) *Evaluation of the Banks's basic education strategy*, Inter-American Development Bank, Office of Evaluation and Oversight, RE-281.

Kaufman, R. and J.Nelson (2005) "Políticas de reforma educativa. Comparación entre países" PREAL document 33.

Krueger, A. (2003) "Economic considerations and class size" *The Economic Journal* **113**, 34-63.

Lanzaro, J. (2004) "La reforma educativa en Uruguay (1995-2000): virtudes y problemas de una iniciativa heterodoxa" CEPAL *Políticas Sociales*, no 91.

Nelson, J (1999) *Reforming health and education: The World Bank, The IDB, and Complex Institutional Change*, Economic Development Policy Essay no. 26, Overseas Development Council, Washington.

Nickson, A. (2001) "Education Reform in Latin America: Decentralization or re-structuring?" paper presented at Conference on Exclusion and Engagement: Social Policy in Latin America, Institute for Latin American Studies, University of London, 22-23 March 2001.

Paus (2003) "Productivity growth in Latin America: The limits of neoliberal reforms" *World Development* **32**, no.3, 427-445.

Valenzuela, J. (2005) "Partial evaluation of a big reform in the Chilean education system: from a half day to a full day schooling", paper presented at LACEA Conference in Paris, France, October 2005.

Vignoles, A., R. Levacic,, J. Walker, S. Machin, D. Reynols (2000) “The relationship between resource allocation and pupil attainment: a review” Centre for the Economics of Education, London School of Economics and Political Science, working paper.

APPENDIX:

1) Production of labour

Individuals enter into the system as raw inputs and pass to later stages as processed inputs as they accumulate skills. Whether they continue studying or go to the labour market, they take with them the amount of knowledge accumulated through the education process.

The number of entrants to the system is assumed constant and, according to the time of exit, labour formation follows the scheme: (a) low-skilled (LS) labour: those students that exit the system with complete or incomplete primary schooling; (b) medium-skilled (MS) labour: those students that exit the system with complete or incomplete secondary; (c) highly skilled (HS) labour: those students that exit the system with complete or incomplete university. They are defined as follows:

$$LS = \sum_k \left[\sum_{i=1}^{6} \theta_{iPk} E_{iPk} f_{i-1Pk} + \theta_{TPk} E_{6Pk} f_{6Pk} + \theta_{1Sk} E_{1Sk} f_{6Pk} \right]$$

where f_0 corresponds to the state previous to the accumulation of knowledge, and θ_{TPk} is the transition dropout rate after completing primary (6 years).

$$MS = \sum_k \left[\sum_{i=2}^{6} \theta_{iSk} E_{iSk} f_{i-1Sk} + \theta_{TSk} E_{6Sk} f_{6Sk} + \theta_{1Uk} E_{1Uk} f_{6Sk} \right]$$

where θ_{TSk} is the transition dropout rate after completing secondary (6 years).

$$HS = \sum_k \left[+ \sum_{i=2}^{4} \theta_{iUk} E_{iUk} f_{i-1Uk} + (1 - \theta_{4Uk}) E_{4Uk} f_{4Uk} \right]$$

So, the present value of total labour produced ($PVTL$) is given by:

$$PVTL = PVLS + PVMS + PVHS$$

where

$$PVLS = \sum_{t=1}^{T} \frac{w_t LS_t}{(1+d)^t}$$

$$PVMS = \sum_{t=1}^{T} \frac{w_t MS_t}{(1+d)^t}$$

$$PVHS = \sum_{t=1}^{T} \frac{w_t HS_t}{(1+d)^t}$$

and w_t is the market wage, and d is the discount factor. Three time horizons are considered: (a) short term: 5 periods, for direct impact of policies on education system; (b) medium term: 25 periods, enough to include the accumulative effects of the reform on the education system; (c) long term: 50 periods, sufficient to include both studying time and working life of individuals.

2) Scenarios for sensitivity analysis

The values of parameters for sensititvity analyisis are the following, for scenario A (moderate elasticities and low heterogeneity) and scenario B (high elasticities and high heterogeneity):

	α_A	α_D	δ_A, ρ_A	δ_D, ρ_D
Scenario A	0.6	0.7	0.1	0.2
Scenario B	0.3	0.9	0.2	0.9

TABLES

Table 1 Government expenditure required for alternative targets
Sensitivity analysis.

	Scenario A	*Scenario B*
Policy 1	37.17	70.75
Policy 2	922.95	112.22
Policy 3	191.97	67.35

Note: Scenarios are A (moderate elasticities and low heterogeneity) and B (high elasticities and high heterogeneity). Policy 1 targets quality at secondary level, policy 2 targets dropout rates at secondary level, and policy 3 targets completion rates at university level.

Table 2 Focused over generalist policies: differences in labour produced. (Differences in percentage changes). Sensitivity analysis.

Time horizon	*Scenario A*	*Scenario B*
Short run	-0.55	-0.16
Mid run	-1.76	0.57
Long run	-2.01	0.58

Note: Scenarios are A (moderate elasticities and low heterogeneity) and B (high elasticities and high heterogeneity).

Table 3 Focused over generalist policies: differences in labour produced by type. (Differences in percentage changes). Sensitivity analysis.

labour produced (dif)	*Scenario A*	*Scenario B*
PVHS short run	-1.06	0.39
PVHS mid run	-2.94	0.68
PVHS long run	-3.37	0.60
PVMS short run	-0.28	-0.41
PVMS mid run	-1.20	0.55
PVMS long run	-1.37	0.61
PVLS short run	-0.22	-1.32
PVLS mid run	-0.10	-0.36
PVLS long run	-0.08	-0.31

Note: PVHS present value of highly skilled labour, PVMS present value of medium-skilled labour, PVLS present value of low-skilled labour. Scenarios are A (moderate elasticities and low heterogeneity) and B (high elasticities and high heterogeneity)

Table 4 Labour produced for alternative budget allocations Sensitivity analysis. (Percentage changes)

	Policy 5		**Policy 6**	
Time horizon	*Scenario A*	*Scenario B*	*Scenario A*	*Scenario B*
Short run	2.03	1.46	2.33	1.66
Mid run	5.23	4.75	4.58	3.73
Long run	5.62	5.12	4.87	3.97

Note: Scenarios are A (moderate elasticities and low heterogeneity), and B (high elasticities and high heterogeneity). Policy 5 consists of enhancing basic education, and policy 6 consists of enhancing higher education.

Table 5 Labour produced by type for alternative budget allocations. Sensitivity analysis. (Percentage changes)

	Policy 5		**Policy 6**	
% changes	*Scenario A*	*Scenario B*	*Scenario A*	*Scenario B*
PVHS short run	0.00	-0.08	2.05	1.71
PVHS mid run	2.89	2.07	6.34	5.50
PVHS long run	3.43	2.48	6.93	6.01
PVMS short run	3.29	2.38	2.59	1.70
PVMS mid run	6.83	6.45	3.85	2.98
PVMS long run	7.16	6.82	4.00	3.09
PVLS short run	-1.08	-0.15	0.00	0.10
PVLS mid run	-2.80	-2.00	-0.06	-0.26
PVLS long run	-3.02	-2.24	-0.07	-0.32

Note: PVHS present value of highly skilled labour, PVMS present value of medium-skilled labour, PVLS present value of low-skilled labour. Scenarios are A (moderate elasticities and low heterogeneity) and B (high elasticities and high heterogeneity). Policy 5 is enhancing basic education, and policy 6 is enhancing higher education.