Departamento de Economía
Facultad de Ciencias Sociales
Universidad de la República

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Enhancing the Public Provision of Education: The Economics of Education Reform in Developing Countries

Rossana Patrón

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ENHANCING THE PUBLIC PROVISION OF EDUCATION: THE ECONOMICS OF EDUCATION REFORM IN DEVELOPING COUNTRIES

Rossana Patrón

dECON

Universidad de la República, Uruguay

Resumen

El documentos sostiene que para evaluar en forma comprensiva las reformas educativas en especial en los países en desarrollo los países deberían considerar la tríada formada por calidad-cantidad-equidad de la educación en el corto, mediano y largo plazo en un contexto mas amplio que el propio sistema educativo. No hay una ‘receta’ simple para mejorar la calidad y la eficiencia tanto interna como externa del sistema público de educación pero se pueden extraer algunos resultados generales. En primer lugar, la elasticidad del retorno de la reforma es decreciente con el tamaño del presupuesto adicional asignado, haciendo anti-económica la opción de una reforma que se base exclusivamente en expandir recursos con el objetivo de mejorar el funcionamiento del sistema. De hecho, se muestra que aun modestas metas requerirían, sin políticas mas específicas, enormes incrementos de presupuesto de pobre retorno. En esta dirección el trabajo analiza la capacidad de políticas especificas de incrementar la productividad del gasto en educación, en particular referidas a los grupos menos favorecidos y a la enseñanza básica. En segundo lugar, para evaluar la reforma la dimensión temporal importa: la mayoría de las políticas con retornos marcadamente diferentes en el largo plazo son prácticamente indiferenciables en sus méritos de corto plazo, y a veces políticas que son mas productivas en el corto plazo son menos convenientes que otras alternativas en el largo plazo, por tanto en la selección de políticas es relevante el horizonte temporal que utilizan los tomadores de decisiones. En tercer lugar, los efectos de las reformas son acumulativos, y evaluar las reformas por meritos, en general modestos, de corto plazo sería miope y puede exponer la reforma al riesgo de reversión o asimismo detener futura inversión en el sector.

Palabras clave: educación pública, países en desarrollo, desarrollo de recursos humanos

JEL: I28, O15

Abstract

The paper argues that a comprehensive evaluation of education reform in particular in developing countries needs considering the ‘triangle’ quality-quantity-equity of educational policies in the short, medium and long term in a broader context than the education system itself. There is no simple “recipe” for improving quality and internal and external efficiency in the public education system but some general results are found. Firstly, that the elasticity of the return of the reform is decreasing with the size of increased budget, making anti-economical the reliance on a reform consisting in more resources only to significantly improve the poor performance of the system. Indeed, very modest target set to improve the system performance, would require -without more sophisticated policies- huge increments in budget with a poor return. In this sense the paper investigate the capacity of focused policies to improve the productivity of the education expenditure, in particular toward basic education or the disadvantaged students. Secondly, the timing of the reform matters: most policies with very different return in the long term are almost undistinguishable by their short run merits, and 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 the policy makers. Thirdly, effects of the reform are accumulative, and to evaluate the reform by modest, in general, short run merits is myopic and may put the reform at risk of reversion or to deter future investment in the sector.

Key words: public education, developing countries, development of human resources

JEL: I28, O15

1: INTRODUCTION

While there has been a successful policy towards the expansion of enrolments world wide not all countries benefit equally from this policy. During the period 1970-1997 African and Latin American countries enrolments in primary, secondary and tertiary education have increase well above world average rates, and Asian countries have increase enrolments above world averages in secondary and tertiary education (UNESCO, 2000). As there has been spectacular increase in educational attainment in developing countries there seems to be a tendency to convergence in stocks of skills worldwide, however, this convergence in educational attainment did no mean that less inequality. While the developed world per capita incomes grew at an average annual rate of 3.11% during the period 1990-2000, developing countries (excluding China and India) grew only at 0.69% (Salvatore, 2004). Moreover, the empirical evidence of the contribution of education to growth is mixed as surveyed for instance by Temple (2000).

Educational policies do play an important for growth, however, not all of them are equally effective and there is not a straightforward policy to promote growth. By the one hand, the quality of the education provided matters. As claimed for instance by Dessus (2001) massive enrolment in developing countries have deteriorated education quality, reducing significantly the capability of education to generate growth. By the other hand the composition of the expenditure in education also matters. Gemmel (1996), for instance, provides evidence that human capital effects on growth at primary level are more important in low income countries, at secondary level for higher income developing countries, and at tertiary level for developed countries. Dabla-Norris and Matovu (2002) also argues that allocation matter for growth and that in developing countries education expenditures is often misallocated resulting in an inefficient and inequitable provision. As an example he brings the case of sub-Saharan African countries where the share of tertiary education in public spending on education is on the highest in the world. For the case of Latin America, Birdsall et al. (1998), Lopez et al. (1998), Nelson (1999) and Paus (2003) suggest that allocation of resources, inefficiency and inequity in provision are the major culprits for the poor performance of education systems in the region. Paus (2003) claims that failing to address adequately the development of human resources in Latin America has been a crucial factor in explaining the poor performance of these countries over the last decades.

The reality of education systems in many developing countries is that there are widespread problems that hinder delivering the service in adequate quantity and quality, as well as equity issues that are still unresolved, as for example across income groups or gender (see for instance UNESCO, 2000). This is particularly relevant in Uruguay where the performance of the education system is poor and resources are scarce. Resources applied to education in Uruguay are low (3.6% of GDP) not only in comparison with industrial countries (5.3% average) but also in comparison with other Latin American countries (4.5% average) (World Bank 2005). In terms of performance, at primary education in 2002 tests 33.7% of students failed languages and 51.7% failed mathematics (World Bank 2005), leading to high rates of repetition (as high as 20% for the first year). Besides this, MEMFOD (1999) research indicates that high repetition rates in primary education have long-term effects on the students' schooling, as it causes over-age population in schools, and those who are over-age are more likely to repeat or dropout in further stages of the educational system. Almost 12% of students dropout after primary school, for those who enter secondary school repetition is near 20% and 26% percent dropout without completing it. In international comparisons of score test also Uruguayan students perform poorly, significantly below OCDE countries, obtaining for instance only 84.4% of the score of their peers in these countries in mathematics (World Bank, 2005)

Other important aspect is that inequality in Uruguay has increased during the last decade and a half and in 2003 about 30% of the population lives in poverty, and in this population children are overrepresented, where 52% of under 15s live in poverty (World Bank, 2005). For this reasons at primary and secondary education about a half of students come from desfavourable backgrounds. Performance indicators for this group of students are significantly worse: at primary education they are about 3 times more likely to repeat than students from favourable background and about 7 times more likely to drop after completing primary school (ANEP, 2003, and MEMFOD, 2003). At secondary education tests in 1999 more than 80% of students of favourable background obtained high marks in maths and language but the percentage was only a half or less for students from poor socioeconomic background (MEMFOD, 2003b). This adverse performance at early stages also leads to inequity in the provision at University level (which is free), where only 15% of students come from low socio economic background (Udelar, 2000). Besides this, the rate of growth of university graduates in Uruguay is on of the slowest in the region (World Bank , 2005b).

This worrying diagnosis of the sector led to several reforms aiming at increase coverage, quality and equity in particular at primary and secondary level, partially financed by international lenders (World Bank, Interamerican Development Bank). After 1996 at primary level the compulsory pre-primary education was introduced and it was implemented a full time school program for disadvantaged students introducing longer teaching hours and a different pedagogic approach, also additional resources were devoted to equipment and teaching material. On test scores of mathematics and language on the final grade of primary (on 1996, 1999 and 2000) revealed that the lower-income segments improved at a faster rate than that of the higher-income groups which could be attributed to the reform (World Bank, 2005).

At secondary level the so-called Plan 96 this reform involved both increased infrastructure, equipment and teaching hours, as well as a change in the pedagogical approach (integration rather than fragmentation of knowledge). The direct effects of an educational reform in secondary education are still being evaluated. This lead to substantial improvement in the systemic performance: dropouts and repetition rates were reduced about 20 %, rates of completion in time rose 23%. It is also significant that the reform led to an improvement in the performance (in terms of repetition and dropout rates) of students of poor socio economic backgrounds which is now near the performance of students of favourable socio economic background in the previous plan (MEMFOD, 2002) .

Many commentators consider the overall effects of the reforms favourably (e.g. Lanzaro, 2004, Bogliaccini and Filgueira, 2003) but whether all these improvements are a fair return to a significant investment in the sector it has yet to be said. Moreover, there have not been any attempt to estimate the overall benefits of this improvement, or more specifically, to estimate the return of the investment in this reform in the long term. It seems clear that evaluate the return of reform only by 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 sustentability 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.

The paper argues that a comprehensive evaluation of education reform in particular in developing countries needs considering the ‘triangle’ quality-quantity-equity of educational policies in the short, medium and long term in a broader context than the education system itself. Considering that the final motivation of education policy is not the education sector itself this paper will investigate the long term repercussions of alternative today’s policies. More precisely, it analyses the effects of generalist and focused policies on the education system and on the formation of human resources in different time horizons. It also sheds light on what is still to be done to be able to asses more comprehensively any education reform.

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 comments on specific policies based on simulation exercises. Section 5 presents the results of the simulations. Section 6 concludes. An appendix list initial values of variables as well as presents elasticities for sensitivity analysis.

2: MODELLING THE EDUCATION SECTOR

The activity that provides educational services has been analysed extensively in the literature. The input-output analysis assumes that there is a relationship between resources applied to education and the production of knowledge, however there is no complete agreement with this assumption as efficiency and effectiveness issues may make the relationship between resources and educational output much more complex.

The education sector is modelled following the commonly adopted approach in the education production function literature in which inputs (teachers, schools, equipment, etc.) add skills to students using a given technology, but dissagregated for relevant variables (e.g. income group, gender, rural or urban, etc.). It also 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.

In this paper the selected dissagregation is by level, grade and type:[1] individuals accumulate knowledge gradually through passing successfully from one grade/level to the next. This detailed specification of the sector is introduced in order to analyse the process of the accumulation of knowledge and its interaction with the labour market. That is, the individual enters the labour market sooner or later depending on how successful his/her schooling life has been, and the individual goes to the market more or less qualified, depending on the last grade successfully completed and the quality of education received. So, the accumulation of skills depends both on the quantity and quality of education received by individuals.

There is obviously a trade-off between increasing the total output of the education system and the cost of doing so. At one extreme the system could be set up so that each student was taught according to his/her needs and therefore no student would repeat. This would be very expensive and it is likely to be 'inefficient' in that the marginal benefit to society from a more highly educated workforce would be less than its marginal cost to society, making it an 'inefficient' use of resources. At the other extreme treating all students identically would be likely to make the repetition and drop-out rates uneconomically high. It is therefore probable that an intermediate system where there is some differentiation (e.g. streaming/setting) and students are allowed to repeat would be superior. It would however imply that some students would still drop-out, so that it may be argued that some resources are being 'wasted'. The measure of the 'inefficiency' of the education activity used in this paper is the proportion of resources devoted to education that are not transformed into skills (knowledge in successful students).

The introduction of a dessaggregation in the production of education as well as a public provider of education gives a flexible framework for the analysis of efficiency, quality and equity issues. As repetition, dropouts, poor quality and unsuccessful transitions throughout the system or into the labour market are particularly serious problems in Latin American countries, the approach adopted here allows us to take into consideration the obstacles to progression throughout the system, repetition and dropping out.

2.1: General settings

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 dropout and repletion rates are negatively related to embodied knowledge in students, and the third one is that complementary to resources is different for advantaged and disadvantaged students and across grades and levels.

The output of education activities as a grade-level-type specific flow variable, is then:

$$Q_{ijk} = F_{jk}(K_{ijk}, E_{ijk}) \tag{3.1}$$

where i represents the grade, j the level, and k the student's type. Q_{ijk} is the output of the education activity (subject to constant returns to scale) of grade i in level j using the resources allocated to it, K_{ijk}, and given the number and type of students currently enrolled, $E_{ijk}\,.\,Q_{ijk}$ represents the amount of knowledge provided by the service but not necessarily transmitted to students as there is some wastage due to inefficiencies in the system.

[1] : A 'level' is a sub-system (e.g. secondary education), a 'grade' is a step in a level, and 'type' refers to a student's characteristics (innate ability, socio-economic background, etc.)

An additional assumption is introduced for student type. When students are heterogeneous it may be educationally convenient to treat them differently. For instance, individuals with lower ability may require more teaching hours to help them keep up with the more able students, or individuals from poor socio-economic background may require school meals or counselling services for themselves or their families. As a good socio-economic background reinforces the formation of skills at home as well as the motivation to acquire them (Heckman and Masterov, 2004), individuals with lower ability or poor socio-economic background are included in the same group (disadvantaged). Students from the disadvantaged group may be more costly to educate, so it is assumed that the production of knowledge in this group is lower than in the advantaged group, for a given certain level of resources. Similarly, as in Sautu (1999), school may compensate for the negative effects of poverty, or more generally, a disadvantaged condition. Thus a further assumption is that the responsiveness of this group to increased resources is higher.

To be more precise, assuming a Cobb Douglas functional form for (3.1):

$$Q_{ijk} = A_{ijk} K_{ijk}^{\alpha_{ijk}} E_{ijk}^{1-\alpha_{ijk}} \qquad 0 < \alpha_{ijk} < 1 \tag{3.2}$$

where A_{ijk} is the scale parameter and α_{ijk} is the elasticity of output with respect to capital input. The above considerations imply the assumptions $A_D < A_A$ and $\alpha_D > \alpha_A$ i.e.: a given level of educational inputs produces a lower level of skills in individuals from the disadvantaged group but the responsiveness of this group to increased resources is higher.

From (3.2) the educational output per student is given by:

$$q_{ijk} = A_{ijk} \left(\frac{K_{ijk}}{E_{ijk}} \right)^{\alpha_{ijk}} \tag{3.4}$$

For each student q_{ijk} is the amount of knowledge embodied in him/her on the successful completion of a grade which builds his/her human capital, which is grade-level-type specific. As such, low values of the 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 by the sector is assimilated differently by heterogeneous students, school quality differs across student type, i.e. they cannot get the same amount of knowledge for identical application of resources. For this reason the parameters α_{ijk} A_{ijk} are student-type specific, and it explains the differences in school quality driven by students differences and not by actions of the providers of the service, hence, for the same level of resource intensity the technology of education provides a lower 'quality of education' to the disadvantaged students.

Individuals enter the system without previous knowledge, and after completing basic education have acquired elementary literacy and numerical skills, which makes them capable of going either to further education or to work. Previous attainment enables future success, or as Heckman and Masterov (2004) put it, skills begets skills. This is reflected in the cumulative nature of the learning process by the accumulation of q_{ijk} during the years of schooling using the indicator:

$$f_{nmk} = \sum_{j=1}^{m} \sum_{i=1}^{n} q_{ijk} \tag{3.5}$$

where f_{nmk} is the total endowment of knowledge accumulated per student in group k who has completed up to grade n of level m.

The indicator f_{nmk} in (3.5) measures the number of efficiency units of skills that a student of group k has accumulated up to grade n and level m, and equates to the concept of human capital.

Ideally, f_{nm} should reach a value f^*_{nm} which represents the qualifications that would be embodied following the *best practice* (any student type). Overall failures in the subsystem might prevent the students reaching f^*_{nm}, implying that there will be a gap between the 'nominal' and 'real' qualification of students. For instance, completing basic education is usually the nominal qualification required to access higher education or to get a job; however if the real qualification is poor, individuals with 'complete' basic education may not be suitably prepared for work or higher education.

Failure to deliver the best practice undermines future success of students within and outside the education system. The gap between f_{nm} and f^*_{nm} is an indicator of the system's underperformance. Measures of this gap are difficult to obtain; however, it may be proxied by international comparisons of test scores by grades, at the same time international comparison may help to set a target in a reform for an under performing system.

A necessary distinction is between the quantity and the quality of schooling. For example, all the students completing secondary school have the same nominal qualifications; however, it is not necessarily true that they have received the same 'quality of education' (i.e. that they have embodied the same amount of educational output). If comparisons are made within a country between the public and the private sector, or if comparisons are made across countries, or if comparisons are made over time (today's students and an earlier cohort), it is highly likely that they have received a quite different quality of education.

2.2: Repetition and dropout rates

Repetition rates are modelled depending of the amount of knowledge individuals manage to get in a school year, as follows:

$$\gamma_{ijk} = b_{ijk} q_{ijk}^{-\rho_{ijk}} \qquad 0 < \rho_{ijk} < 1 \quad , \quad b_{ijk} > 0 \tag{3.6}$$

where the parameter b_{ijk} determines the level of the rate for a given q_{ijk}, and ρ_{ijk} measures the responsiveness of the rate to improvements in q_{ijk}, being $\frac{\partial \gamma_{ijk}}{\partial q_{ijk}} < 0$.

The parameters b_{ijk} and ρ_{ijk} are grade-level-type specific to allow variation in the way success depends on school quality (q_{ijk}) throughout the system. This formulation of repetition rates has implications on equity on the provision of educational services. As the disadvantaged group is more costly to educate than the advantaged one, for the same amount of resources school quality is poorer for them, hence the chances of success are lower for them. As education is publicly provided all the school age population has equal access; however, it is a matter of policy if they receive the same learning opportunities (i.e. chances of success).

Considering also (3.4) the formulation of repetition rates in (3.6)also implies:

$$\frac{\partial \gamma_{ijk}}{\partial K_{ijk}} < 0 \text{ and } \frac{\partial^2 \gamma_{ijk}}{\partial^2 K_{ijk}} > 0$$

i.e. rates are decreasing with resources at decreasing marginal rates, reflecting the assumption that it would be prohibitively expensive the complete abatement of repetition rates. Using (3.3) and (3.4) the relationship between repetition rates and resources can be measured by the elasticity:

$$\varepsilon_{ijk} = -\rho_{ijk} \ \alpha_{ijk}$$

where the above expression shows that the reduction of the repetition rate depends on the elasticity of the educational output with respect to resources and the elasticity of the repetition rate respect to school quality (q_{ijk}).

The occurrence of repetition affects the average duration of studies increasing the opportunity cost of for the student, and at the same time it increases the actual cost of the educational service provided to them. Both wide coverage at entry level and the completion of the level as well as the timely progression to subsequent levels are important to assess the efficiency in the provision of the service. All those who repeat or drop out without completing a course will fail to accumulate any knowledge in spite of the resources devoted to that aim, hence it will imply waste of time and resources. Improving completion rates and reducing repetition rates will improve the efficiency of the service, when efficiency is measured by the percentage of successful students for a given expenditure.

However, there is a trade-off between the quality of education and the number of students to be educated given a fixed amount of resources. An excessive emphasis on increasing the coverage of aged-school population could (and often has) lead to a deterioration of the quality of education and so to a devaluation of the 'nominal qualifications'. Henceforth, the issues of coverage and quality have to be tackled by a carefully planned policy.

According to Barnes (1999) students drop out of school if they 'fail to learn', and according Hanushek (2004), 'higher student achievment keeps students in school longer'. Early dropouts means that students leave the system with poor human capital accumulation, which will mean a low productivity in the world of work. Hence, school quality is a major determinant of students future inside and outside school, and the following functional form is assumed:

$$\theta_{ijk} = a_{ijk} q_{ijk}^{\ -\delta_{ijk}} \quad 0 < \delta_{ijk} < 1 \quad , \quad a_{ijk} > 0 \tag{3.7}$$

where a_{ijk} and δ_{ijk} are grade-level-type specific scalars, and the same considerations on the functional form in expression (3.6) apply.

Birdsall et al. (1998) suggest that expanding quantity and improving quality at basic education level stimulates the demand for higher education, feature that is reflected in this modellisation. Early dropouts not only reduce the potential demand for higher education but also as, as Anderson and Randall et al. (1999) argue, tend to perpetuate a low productivity workforce, feature that is also reflected in this modellisation as will be described below.

2.3 Production of a mix of skills

The flow of students throughout the system starts with basic education, which produces both unskilled workers and intermediate inputs to higher education. 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 total of units of skills inside the system ready to move into the labour market or into the system itself include both the current output of the education sector and the students' previous attainment (i.e. the previous production of the education sector embodied in students), i.e. for level j (any grade and student type):

$$L_j = n_j f_j$$

where , $n_j = E_j(1-\gamma_j)$, E_j is the enrolment in level j , and γ_j is the average repetition rate.

So, the pattern of endowment growth is given by the timing of exit 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. Hence, the human capital embodied by newcomers into the labour force varies with any change in the quality and efficiency of the system.

The present value of total labour (PVTL) measures the value of the stream of labour production (valued by the respective salary) and shows the value of inputs produced (human resources) or similarly the present value of future income of today's students.

3: EDUCATION POLICIES

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 in this section.

The government allocates an exogenously determined budget for education activities. This is modelled as a two stage process: in the first stage the government distributes resources within the educational sector given a total budget, and in the second, educational institutions allocate internally the resources received across types and grades.

3..1: Government

Education is publicly provided, which makes the problems of coverage and retention of the system dependent on the performance of the sector itself. Ideally, in order to benefit the economy and society the education system would pursue the provision of high quality education to as many students as possible, so the production of skills would be maximised (i.e. the amount of labour delivered to the labour market).

In the modelling of the decision taking process used here it is assumed that the central authority concentrates in the quantity of successful students (n_j) for the whole system, while the relevant education authorities deal with 'quality' (q_{ijk}) and quantity (n_{ijk}) of the provision across grades and groups. An alternative assumption would be the central authority to focus both on quantity and quality but as students are heterogeneous and each level-grade has its specificity it does not seem reasonable to assume the central authority will have all this information to determine 'school quality' for all grade-type-levels, so it cannot be incorporated in their decision rule.

A more straightforward decision rule for the government would be to allocate funds according to the number of students (E_j) in each level, which may intend to provide a service with similar resource intensity per student across levels. However, this rule does not take into account the specificity of each level (e.g. percentages of repeaters) and how levels are linked (e.g. early exits), so allocating funds according to the number of students will not necessarily improve performance similarly across levels and is likely not to be the best way to ease the transit inside the system (i.e. to reduce repetition and dropouts so as to increase the number of successful students in the whole system).

The government's utility function takes the following form:

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

The parameter ϕ_j represents the government's preferences, and is an indicator of the weight given by the government to the development of human resources. The government can tackle inefficiencies across the system selectively according to its preferences. The higher is U the higher will be the internal efficiency of the subsystem

The utility function assumes that the government regards as desirable that as many people as possible complete as many academic years as possible, ideally in the regular number of years formally scheduled but otherwise without a long delay. In the pursuit of this objective it seeks to improve the capacity of the system to deliver an appropriate flow of qualified students/workers both internally and into the labour market.

The optimisation programme can be formulated as:

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

where $\overline{K}$ is the total resources destined to education, and ϕ_j is the weight given by the government to each level. According to this programme the government will allocate resources so as to maximise the number of students completing each subsystem by seeking to reduce dropouts rates and repetition rates at all levels.

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 government's utility. The model allows the government to affect 'completion in time' rates by changing the level and allocation of the budget. Progression rates across levels are the result of the functioning of a system that is either allowing students to learn or not (in this latter case, it acts as if it is rejecting students).

3.2: The education authority's policy

Once resources are allocated to each level, the education authorities will seek to optimise the use of these resources by students' type and grades, as is discussed next.

i) Types

The education authority's utility depends on the overall quality across groups, as follows:

$$\underset{K_{jk}}{Max} \quad \prod_k \left(q_{jk}\right)^{\mu_k}$$

$$s.t.\ K_j = \sum_k K_{jk} \qquad (3.15)$$

$$q_{jk} = f\left(k_{jk}\right)$$

where K_j is the amount of resources allocated by the government to level j in the first step, and the parameters μ_k represent the educational authority's preferences over education provision across groups.

The allocation resulting from the first order conditions is

$$K_{jD} = \frac{\alpha_{jD}\mu_{jD}}{\alpha_{jD}\mu_{jD} + \alpha_{jA}\mu_{jA}} K_j$$

$$K_{jA} = \frac{\alpha_{jA}\mu_{jA}}{\alpha_{jD}\mu_{jD} + \alpha_{jA}\mu_{jA}} K_j$$

The general result for any number of types is:

$$K_{jk} = \frac{\alpha_{jk}\mu_{jk}}{\sum_k \alpha_{jk}\mu_{jk}} K_j$$

It is apparent that by choosing μ_k appropriately in program (3.15) the authorities may consider different approach in their policies, i.e. egalitarian, elitist or progressive policies. In particular, an egalitarian approach, egalitarian in terms of the benefit that individuals receive from education, should ensure that $q_A = q_D$. In this case the following two equations determine the allocation of resources.

$$q_F = q_D$$

$$K_j = \sum_k K_{jk}$$

we have a system of two equations and two unknowns (K_{jk}), which gives the solution:

$$K_{jk} = \frac{E_{jk} A_{j\bar{k}}^{\frac{1}{\alpha}}}{\sum_k E_{jk} A_{j\bar{k}}^{\frac{1}{\alpha}}} K_j$$

where $k = A, D$ and the sub-index $\bar{k}$ indicates 'different from k'.

ii) Grades

Once resources are allocated to each type the education authorities seek to optimise the use of these resources across grades.

The education authority optimisation problem may be formulated similarly as for the central authority, as follows:

$$\begin{aligned}
\underset{K_{ijk}}{Max} \quad & U = \prod_i \left[n_{ijk} \left(1 - \theta_{ijk}\right) \right]^{\phi_i} \qquad \sum_i \phi_i = 1 \\
& s.t.\ \overline{K}_{jk} = \sum_i K_{ijk} \\
& n_{ijk} = \left(1 - \gamma_{ijk}\right) E_{ijk} \\
& \gamma_{ijk} = c_{ijk} q_{ijk}^{-\rho_{ijk}} \\
& \theta_{ijk} = a_{ijk} q_{ijk}^{-\delta_{ijk}} \\
& \overline{K}_{jk}\ ,\ E_{1jk}\ \ given
\end{aligned} \tag{3.16}$$

where the paramenter ϕ_i shows the preferences of the education authority over the provision across grades, which is solved similarly as program (3.15).

By means of these two programmes the education authorities determine the provision across grades and types, where they will have to compromise between quality of the provision across groups (program 3.15) and total number of successful students (program 3.16).

4 POLICY OPTIONS: SOME SIMULATION EXERCISES

Reforms have been indeed implemented in Latin America. Although this led to some progress, mainly in terms of enrolments, Shiefelbein et al. (1998) provide a very critical view of this process, asserting that most of the reforms that have been made disregard the cost-effectiveness criterion. They argue, based on a survey of experts' opinions, that some expensive and ineffective measures have been taken (e.g. increasing teachers' salaries), while some cheaper and effective ones have not been favoured by reformers (e.g. encouraging parents to read to their children). In the particular case of Uruguay the reliance in focused policies seems to have worked well at least in comparison to other reforms e.g. Chile (Bogiaccini and Filgueira, 2003).

According to Hanushek (2004) an effective school reform is that with positive effects on GDP, i.e. costs must be less than benefits in order to be feasible. This section intends to give elements along this line to asses more comprehensively any education reform, arguing that, that the evaluation of the economic effects of the education reform in particular in developing countries needs considering issues of quality-quantity-equity of educational policies in the short, medium and long term in a broader context than the education system itself. Notwithstanding this, the section remain under the partial equilibrium approach.

Some alternatives to improve the efficiency of education expenditure will be investigated by means of a series of simulation exercises. An application of the model to a stylised version of the Uruguayan education system is carried out (for a wide range of values of unknown parameters) in a partial equilibrium approach for the short, mid and long term. Alternatives values for α and ρ and δ (the unknown parameters in the assumptions in section 2.1) are tried in the simulation exercises for the sensitivity analysis. The combination of two alternatives gives four cases for the sensitivity analysis. For α the options are: alternative *a* complementary is moderate and similar for advantaged and disadvantaged groups, and alternative *b* complementary is very dissimilar groups. For ρ and δ the cases are: alternative *L*: responsiveness of rates is low (other factors no modelled dominate, i.e. motivation), and alternative *H*: responsiveness is high. So the four cases for the sensitivity analysis are: *aL* sets α = 0.6 and 0.7, ρ =0.1 and 0.2; *bL* sets α =0.3 and 0.9 ρ =0.1 and 0.2; *aH* sets α =0.6 and 0.7, ρ =0.2 and 0.9; *bH* sets α =0.3 and 0.9, ρ =0.2 and 0.9.

The productivity of educational expenditure is measured the present value of the stream of labour production (valued by the respective salary) which shows the value of inputs produced (human resources) or similarly the present value of future income of today's students. The number of entrants to the system is assumed constant and according to the time of exit labour formation is assumed to follow the scheme: a) informal labour: those students that exit the system with primary complete or incomplete; b) unskilled labour: those students that exit the system with secondary or baccalaureate complete or incomplete; c) skilled labour: those students that exit the system with university complete or incomplete. Three time horizon are considered: a) short term: 5 periods, direct impact of policies on education system (government time horizon to make plans); b) medium term: 25 periods, enough to include the accumulative effects of reform on education system with and without repetition (may include some working periods for the fastest); c) long term: 50 periods, enough to include studying and working live of individuals.

These are the main findings:

1) more money is not the ultimate solution…

Analyses of the Latin American situation by Birdsall et al. (1998), Lopez et al. (1998), Nelson (1999) and Paus (2003) strongly criticise the educational policies in the region, where they argue that more money is not the only thing needed to produce higher levels of educational capital in the population in Latin American countries: allocation (across gender, region, socio-economic groups, etc.) and efficiency matters, and thus far-reaching reforms are required first.

Indeed, the effectiveness of increases in the budget to improve students' performance is limited when the assumption of responsiveness of repetition and dropout rates is positive but at decreasing marginal rates holds. Besides this, increases in the budget will also increase the quality gap across students type if the assumption of greater responsiveness to resources for disadvantaged students holds, this is because initial success in coverage for disadvantaged group will affect quality adversely for the group.

To investigate this issue this experiment simulates a generalist policy (policy one) consisting of 10%, 50%, 100%, and 200% increments in the budget (with sensitivity analysis in all cases). The results are presented in table 1 which presents the elasticities of present value of total labour (PVTL) in the short, medium and long term. The table shows that the elasticities of PVTL are decreasing in increasing increments in resources, this is, while long term increment rate for varies between 0.41 to 0.58% for all cases when increments to the budget are modest, it only ranges between 0.35 to 0.48% when the increment reaches 200%. This effects seem to rule out the possibility of a significant improvement of a system performing poorly even with huge additions to the budget. It also shows that in all cases the short term gains are between a third and a quarter of long term gains making myopic the evaluation of the reform by just its short run merits.

Not only the productivity of the expenditure is decreasing with the amount of resources, but also generalist policies do not address inequality issues. This is, more resources will be able to improve coverage but without changes in policy it does not matter how big is the increase in the budget it will be ineffective to close the gap across groups in the short or long term.

Table 1 Elastitities of labour produced (PVTL) for alternative policies (sensitivity analyses)

	aL			*bL*			*aH*			*bH*		
	short	mid	long	short	mid	long	short	mid	long	short	mid	long
10	0.16	0.46	0.52	0.13	0.37	0.41	0.14	0.51	0.58	0.11	0.41	0.46
50	0.15	0.44	0.49	0.12	0.35	0.39	0.14	0.48	0.54	0.11	0.38	0.42
100	0.15	0.42	0.47	0.12	0.33	0.37	0.13	0.46	0.52	0.1	0.36	0.4
200	0.13	0.38	0.43	0.11	0.31	0.35	0.12	0.42	0.48	0.09	0.34	0.38

Note: sensitivity analysis for cases *aL*, *bL*, *aH* and *bH* described in the text

2) even modest targets would be very costly…

The capacity of generalist policies to meet certain targets at different levels of the education system is investigated. Three alternative targets to improve systemic performance in a period´s time are tried 1) targeting productivity, 2) targeting completion rates 3) targeting number of graduates. The results of the simulation exercises are presented in table 2.

Policy 2 aims at improving 20% average productivity at secondary level in the mid term. Table 2 shows that this target would require an increase between 37.17-70.72%, a policy that would receive a return between 39-55% in the long term. The policy under scenarios H gives a very low in the short term but return moderately high in the longer term (higher than scenarios L that are higher in the short term).The target of policy 3 is to reduce average dropout rates at secondary level in the mid term. This policy, as the results of the simulation show in table 1, would be very expensive, requiring between 1 to 9 times the original budget. However, note that the target is very modest, a reduction of 20% of dropout rates at average secondary dropout rates would reduce them from 10% to 8% in the mid term, meaning that there still will and 8% of students leaving the system without completing compulsory education. The policy gives a wide range of return between 0.29 to 0.51% according to each scenario showing the sensitivity of the results to changes in parameters. The target of policy 4 is to increase number of university graduates 10% in the mid term, a target that is not very ambitious but would require an increment in resources between 60% to double the current budget.

Table 2 Government expenditure and labour produced for policies 2, 3 and 4 (percentage changes and elasticities)

	policy 2				policy 3				policy 4			
% ch	aL	bL	aH	bH	aL	bL	aH	bH	aL	bL	aH	bH
PVTL short	5.85	6.62	5.99	7.36	91.08	78.43	15.14	11.23	25.96	23.02	8.24	7.03
PVTL mid	16.57	18.61	21.09	26.24	263.14	225.63	52.85	40.15	73.73	64.87	28.86	25.06
PVTL long	18.54	20.77	23.72	29.34	296.83	253.67	59.57	44.97	82.75	72.55	32.47	28.02
G	37.17	53.71	43.43	70.75	922.95	881.27	117.36	112.22	191.97	210.11	60.64	67.35
elasticities												
short run	0.16	0.12	0.14	0.10	0.10	0.09	0.13	0.10	0.14	0.11	0.14	0.10
mid run	0.45	0.35	0.49	0.37	0.29	0.26	0.45	0.36	0.38	0.31	0.48	0.37
long run	0.50	0.39	0.55	0.41	0.32	0.29	0.51	0.40	0.43	0.35	0.54	0.42

Note: sensitivity analysis policies 10, 11 and 12 for cases *aL*, *bL*, *aH* and *bH* described in the text

Dispersion of returns is lower in the short run but they differ substantially in the long run, making the selection of policies on short term merits not very different, i.e. there is not very strong preference for anyone. In the short term they have all low not very distinguishable return (around 10%) whereas in the long term returns vary between 0.29 to 0.55%. Even when the specific targets are modest, the size of the resources needed make these reform unrealistic, leading to conclude that generalist policies are very costly, even when considered the long term gains.

3) focused policies may be more efficient…

Birdsall et al. (1998) point out that it is more than a problem of the level of spending on education, since the problem is that the sector has failed to use effectively its resources and 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 failing to develop the human capital base has been a major drawback to the development of the region. Lopez et al. (1998) also stress the importance of quality and equity in the provision of education in obtaining positive economic effects.

The presence of student heterogeneity may impose an efficiency-equity dilemma on policymakers. Applying relatively more resources to the disadvantaged group operates towards obtaining similar results across groups; however, this comes at the cost of sacrificing a better quality of education for the advantaged group. 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 Birdsall et al. (1998) argue that 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. Allowing for heterogeneity of students, equal access to the educational system does not imply equal benefits for all students. Moreover, Lopez et al. (1998) argue that the distribution of education matters for economic development. These authors present empirical evidence that an unequal distribution of education tends to have a negative impact on per capita income in many countries. So, rather than equal access to education individuals may, or should as OECD (2004) put it, be offered access to 'equivalent learning opportunities', and this also will be investigated in the simulation exercises.

This section investigates the convenience of applying focused rather generalist policies. Policy 5 consists of allocating more resources to education but introducing changes in education authorities preferences respect to the quality of the service provided across students´ type, the exercise simulate an increment of the budget of 10% and 25% inc preference disadvantage all levels. Table 3 shows the results of policy 5 against the generalist policy one (10% increase in budget without changing preferences) for the production of the different types of labour as well the elasticity of total labour produced.

The effect of this reform on the productivity of expenditure is very different for the different set of parameters. In the long term under the assumption *a* elasticities deteriorates whereas under assumption *b* the policy is as good or better than policy one. In particular, under scenario *bH* the policy not only increase the productivity of expenditure, it will also produce a similar increment for skilled and unskilled labour in the long term against the production of informal labour. In the short run the return of the policy in this case is worse than policy one but is better in the long term, making the time horizon of policy makers relevant in choosing one of the other policy on grounds of its economic merit.

Then, focused policies seeking to reduce inequality may be the more efficient option. This policy may favour the production of labour, as more students of the group more at risk of dropping out early (the disadvantaged) are now able to reach further stages of the system due to a focused policy. So this policy not only increase the equity in the provision to disadvantage group by increasing the coverage and quality of education for the group, it may be a case (case bH) where the policy is better also in economic sense than a generalist one.

Table 3 Labour produced in focused over generalist policy (differences in percentage changes and elasticities)

difference in % ch	aL	bL	aH	bH
PVLSN short run	-1.06	-0.06	-0.67	0.39
PVLSN mid run	-2.94	-0.59	-1.51	0.68
PVLSN long run	-3.37	-0.75	-1.80	0.60
PVLUN short run	-0.28	0.22	-0.87	-0.41
PVLUN mid run	-1.20	0.32	-0.95	0.55
PVLUN long run	-1.37	0.33	-1.04	0.61
PVLIN short run	-0.22	0.32	-1.57	-1.32
PVLIN mid run	-0.10	1.15	-1.14	-0.36
PVLIN long run	-0.08	1.25	-1.13	-0.31
PVTL short run	-0.55	0.13	-0.82	-0.16
PVTL mid run	-1.76	0.04	-1.14	0.57
PVTL long run	-2.01	0.00	-1.30	0.58
difference in elasticity				
elast short run	-0.05	0.01	-0.08	-0.02
elast mid run	-0.18	0.00	-0.11	0.06
elast long run	-0.20	0.00	-0.13	0.06

Note: PVLSN present value of skilled labour, PVLUN present value of unskilled labour, PVLIN.present value of informal labour. Sensitivity analysis policy 8 for cases *aL*, *bL*, *aH* and *bH* described in the text

4) allocation across levels matter…

Nelson (1999) argues that in many middle-income countries the allocation rather than the level of expenditure is the main problem in the education sector. In the case of Latin American countries Birdsall et al. (1998) show that while the levels of expenditure are not low compared with other developing countries, the results are poorer. On this point these authors argue that in Latin American countries the share of higher education in public expenditure tends to be high (20% on average) compared to East Asian countries (15% on average) which grow faster.

So the issue frequently discussed in the literature is whether the government's priority should be basic or higher education will be investigated. It is simulated alternative policies, Policy 6 and 7 consist of increasing resources to education while increasing the government preference for basic education (primary and secondary) and higher education respectively., which results are presented in table 4. As the table shows, policy 6 improves the productivity of educational expenditure in the long term, from 0.41 to 058% percentage points in policy one to 0.47-0.62, while policy 7 reduces it to 0.37-0.52.

Policy 7 is a long term policy of producing skilled labour but policy 6 is more productive in general. The table shows that policy 5 is a more efficient way to produce skilled labour in the long term, as it produces 2.17-3.43 in the long term while the more expensive policy favouring higher education produces a range 1.32-2.46 of increment of skilled labour in the short term. Then, policy 7 is a short term policy of producing skilled labour so is costlier.

Table 4 Labour produced policies 6 and 7 (percentage changes and elasticities)

	policy 6				policy 7			
% changes	aL	bL	aH	bH	aL	bL	aH	bH
PVLSN short run	0.00	0.02	-0.12	-0.08	2.05	1.32	2.46	1.71
PVLSN mid run	2.89	1.83	2.99	2.07	6.34	4.11	8.21	5.50
PVLSN long run	3.43	2.17	3.68	2.48	6.93	4.49	9.00	6.01
PVLUN short run	3.29	3.06	2.16	2.38	2.59	2.34	1.88	1.70
PVLUN mid run	6.83	6.13	7.12	6.45	3.85	3.40	3.36	2.98
PVLUN long run	7.16	6.42	7.71	6.82	4.00	3.52	3.50	3.09
PVLIN short run	-1.08	-1.05	0.11	-0.15	0.00	-0.03	-0.02	0.10
PVLIN mid run	-2.80	-2.91	0.52	-2.00	-0.06	-0.16	-0.28	-0.26
PVLIN long run	-3.02	-3.15	0.55	-2.24	-0.07	-0.18	-0.32	-0.32
PVTL short run	2.03	1.89	1.32	1.46	2.33	1.92	2.03	1.66
PVTL mid run	5.23	4.44	5.54	4.75	4.58	3.54	4.90	3.73
PVTL long run	5.62	4.74	6.15	5.12	4.87	3.74	5.25	3.97
elasticities								
short run	0.20	0.19	0.13	0.15	0.23	0.19	0.20	0.17
mid run	0.52	0.44	0.55	0.48	0.46	0.35	0.49	0.37
long run	0.56	0.47	0.62	0.51	0.49	0.37	0.52	0.40

Note: PVLSN present value of skilled labour, PVLUN present value of unskilled labour, PVLIN.present value of informal labour. Sensitivity analysis policy 8 for cases *aL, bL, aH* and *bH* described in the text

6: CONCLUSIONS

Due to frictions in the educational system, resources are wasted during the schooling process, and hence the nominal output of the education activities does not measure correctly the contribution of the activity to the economy. Building up the economy's educational capital requires that the students effectively embody the qualifications that the system is offering to them. Failures in doing so imply that the nominal output of the sector and the generation of educational capital may differ significantly. This gap shows that there is an excessive cost in building up the economy's educational capital in comparison with an optimal performance of the educational system.

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 adds to the education production function and human capital accumulation theoretical literature in which it includes the presence of inefficiencies, modelling the role of educational policies on tacking at them. Efficiency, equity and quality in the education system depend on appropriate targeting by government and authorities. There is a trade-off between the quality of education and the number of students to be educated, given a fixed amount of resources. An excessive emphasis on increasing the coverage of school-age population could lead to a deterioration of the quality of education and so to a devaluation of the 'nominal qualifications'. The model presented, by mapping the links from education to the labour market, suggests clear lines along which some of the major drawbacks in the education system affect the labour market and more interestingly how they could be tackled.

The policies discussed allow 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 (skills) 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. Firstly, that the elasticity of the return of the reform is decreasing with the size of increased budget, making anti-economical the reliance on a reform consisting in more resources only to significantly improve the poor performance of the system. Indeed, very modest target set to improve the system performance, would require -without more sophisticated policies- huge increments in budget with a poor return. In this sense the paper investigate the capacity of focused policies to improve the productivity of the education expenditure, in particular toward basic education or the disadvantaged students. Secondly, the timing of the reform matters: most policies with very different return in the long term are almost undistinguishable by their short run merits, and 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 the policy makers. Thirdly, effects of the reform are accumulative, and to evaluate the reform by modest, in general, short run merits is myopic and may put the reform at risk of reversion or to hinder future investment in the sector.

The paper intends to shed some light to progress in the understanding of the economics of education reform in developing countries. It is evident that the return of the reform depend on a set of unknown parameters and show the need to progress in this direction to assess comprehensively the return of any education reform. There still a lot of work to do, in particular in estimation of parameters and collecting comparable data across levels, however, the results of this paper can explain why reforms in Uruguay lead to more satisfactory results than Chile, where focused policies where mainly applied in Uruguay.

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APPENDIX

1) variables

VA(j,t) value added
GAMMA(j,t) repetition rate
THETA(j,t) average dropout rate
QVAF(j,t) real value added fav j
QVAD(j,t) real value added des j
QVAP(ip,k,t) real value added primary by type and grade
QVAS(is,k,t) real value added secondary by type and grade
QVAB(ib,k,t) real value added baccalaureate by type and grade
QVAH(i,k,t) real value added he by type and grade
qp(ip,k,t) output per student primary by type and grade
qs(is,k,t) output per student secondary by type and grade
qb(ib,k,t) output per student baccalaureate by type and grade
qh(i,k,t) output per student he by type and grade
fp(ip,k,t) output per student accumulated primary by type and grade
fs(is,k,t) output per student accumated secondary by type and grade
fb(ib,k,t) output per student accumulated baccalaureate by type and grade
fh(i,k,t) output per student accumulated he by type and grade
q(j,k,t) output per student by type
qpa(t) average output per student primary
qsa(t) average output per student sec
qba(t) average output per student baccalaureate
qha(t) average output per student he
THETAP(ip,k,t) dropout rate primary by grade and type
THETAS(is,k,t) dropout rate secondary by grade and type
THETAB(ib,k,t) dropout rate baccalaureate by grade and type
THETAH(i,k,t) dropout rate he by grade and type
THETAPT(k,t) dropout rate transition after primary type k
THETAST(k,t) dropout rate transition after secondary type k
THETABT(k,t) dropout rate transition after baccalaureate type k
GAMMAP(ip,k,t) repetition rate primary by type and grade
GAMMAS(is,k,t) repetition rate secondary by type and grade
GAMMAB(ib,k,t) repetition rate baccalaureate by type and grade
GAMMAH(i,k,t) repetition rate he by type and grade
E(j,t) students j total
EF(j,t) students fav group in j
ED(j,t) students desf group in j
EP(ip,k,t) students primary by grade and type
ES(is,k,t) students secondary by grade and type
EB(ib,k,t) students baccalaureate by grade and type
EH(i,k,t) students he by type and grade

indexes:
ip grades primary
is grades secondary
ib grades baccalaureate
i grades higher education
j levels
k types

2) initial values of the variables

```
VA.L('p',t)= 1571.715;
VA.L('s',t)= 974.841;
VA.L('b',t)= 1006.125;
VA.L('h',t)= 1009.504;
GAMMA.L('p',t)= 0.091;
GAMMA.L('s',t)= 0.113;
GAMMA.L('b',t)= 0.109;
GAMMA.L('h',t)= 0.330;
THETA.L('p',t)= 0.032;
THETA.L('s',t)= 0.100;
THETA.L('b',t)= 0.169;
THETA.L('h',t)= 0.244;
QVAF.L('p',t)= 486.191;
QVAF.L('s',t)= 344.049;
QVAF.L('b',t)= 413.006;
QVAF.L('h',t)= 687.417;
QVAD.L('p',t)= 1085.524;
QVAD.L('s',t)= 630.792;
QVAD.L('b',t)= 593.118;
QVAD.L('h',t)= 367.036;
QVAP.L('1','f',t)= 194.523;
QVAP.L('1','d',t)= 413.117;
QVAP.L('2','f',t)= 99.149;
QVAP.L('2','d',t)= 238.884;
QVAP.L('3','f',t)= 72.646;
QVAP.L('3','d',t)= 160.048;
QVAP.L('4','f',t)= 51.444;
QVAP.L('4','d',t)= 115.462;
QVAP.L('5','f',t)= 42.404;
QVAP.L('5','d',t)= 96.110;
QVAP.L('6','f',t)= 26.026;
QVAP.L('6','d',t)= 61.904;
QVAS.L('1','f',t)= 163.930;
QVAS.L('1','d',t)= 300.898;
QVAS.L('2','f',t)= 94.637;
QVAS.L('2','d',t)= 173.491;
QVAS.L('3','f',t)= 85.482;
QVAS.L('3','d',t)= 156.404;
QVAB.L('1','f',t)= 201.411;
QVAB.L('1','d',t)= 295.011;
QVAB.L('2','f',t)= 114.566;
QVAB.L('2','d',t)= 161.678;
QVAB.L('3','f',t)= 97.030;
QVAB.L('3','d',t)= 136.429;
QVAH.L('1','f',t)= 341.747;
QVAH.L('1','d',t)= 182.708;
QVAH.L('2','f',t)= 161.811;
QVAH.L('2','d',t)= 86.664;
QVAH.L('3','f',t)= 109.621;
QVAH.L('3','d',t)= 58.361;
QVAH.L('4','f',t)= 74.239;
QVAH.L('4','d',t)= 39.303;
qp.L('1','f',t)= 0.053;
qp.L('1','d',t)= 0.020;
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qp.L('2','f',t)= 0.038;
qp.L('2','d',t)=0.015;
qp.L('3','f',t)= 0.033;
qp.L('3','d',t)= 0.012;
qp.L('4','f',t)= 0.028;
qp.L('4','d',t)=0.010;
qp.L('5','f',t)= 0.025;
qp.L('5','d',t)=0.009;
qp.L('6','f',t)=0.020;
qp.L('6','d',t)=0.007;
fp.L('1','f',t)= 0.053;
fp.L('1','d',t)= 0.020;
fp.L('2','f',t)= 0.093;
fp.L('2','d',t)= 0.036;
fp.L('3','f',t)= 0.128;
fp.L('3','d',t)= 0.048;
fp.L('4','f',t)= 0.157;
fp.L('4','d',t)= 0.058;
fp.L('5','f',t)= 0.183;
fp.L('5','d',t)= 0.067;
fp.L('6','f',t)= 0.204;
fp.L('6','d',t)= 0.075;
qs.L('1','f',t)= 0.057;
qs.L('1','d',t)=0.023;
qs.L('2','f',t)= 0.046;
qs.L('2','d',t)=0.018;
qs.L('3','f',t)= 0.046;
qs.L('3','d',t)=0.018;
fs.L('1','f',t)= 0.262;
fs.L('1','d',t)= 0.098;
fs.L('2','f',t)= 0.308;
fs.L('2','d',t)= 0.116;
fs.L('3','f',t)= 0.353;
fs.L('3','d',t)= 0.134;
qb.L('1','f',t)= 0.082;
qb.L('1','d',t)= 0.037;
qb.L('2','f',t)= 0.068;
qb.L('2','d',t)= 0.030;
qb.L('3','f',t)= 0.067;
qb.L('3','d',t)= 0.030;
fb.L('1','f',t)= 0.435;
fb.L('1','d',t)= 0.171;
fb.L('2','f',t)= 0.501;
fb.L('2','d',t)= 0.200;
fb.L('3','f',t)= 0.567;
fb.L('3','d',t)=0.230;
qh.L('1','f',t)= 0.165;
qh.L('1','d',t)= 0.086;
qh.L('2','f',t)= 0.128;
qh.L('2','d',t)= 0.069;
qh.L('3','f',t)= 0.122;
qh.L('3','d',t)= 0.068;
qh.L('4','f',t)= 0.117;
qh.L('4','d',t)= 0.068;
fh.L('1','f',t)= 0.731;
fh.L('1','d',t)= 0.316;
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fh.L('2','f',t)= 0.843;
fh.L('2','d',t)= 0.374;
fh.L('3','f',t)= 0.960;
fh.L('3','d',t)= 0.438;
fh.L('4','f',t)= 1.073;
fh.L('4','d',t)= 0.503;
q.L('p','f',t)= 0.033;
q.L('p','d',t)= 0.012;
q.L('s','f',t)= 0.050;
q.L('s','d',t)= 0.020;
q.L('b','f',t)= 0.072;
q.L('b','d',t)= 0.033;
q.L('h','f',t)= 0.133;
q.L('h','d',t)= 0.073;
qpa.L(t)= 0.022;
qsa.L(t)= 0.035;
qba.L(t)= 0.053;
qha.L(t)= 0.103;
THETAP.L('1','f',t)=0.031;
THETAP.L('1','d',t)=0.039;
THETAP.L('2','f',t)=0.03;
THETAP.L('2','d',t)=0.037;
THETAP.L('3','f',t)=0.029;
THETAP.L('3','d',t)=0.036;
THETAP.L('4','f',t)=0.028;
THETAP.L('4','d',t)=0.035;
THETAP.L('5','f',t)=0.027;
THETAP.L('5','d',t)=0.034;
THETAP.L('6','f',t)=0.027;
THETAP.L('6','d',t)=0.034;
THETAS.L('1','f',t)=0.111;
THETAS.L('1','d',t)= 0.133;
THETAS.L('2','f',t)= 0.080;
THETAS.L('2','d',t)= 0.097;
THETAS.L('3','f',t)= 0.081;
THETAS.L('3','d',t)= 0.097;
THETAB.L('1','f',t)=0.202;
THETAB.L('1','d',t)= 0.238;
THETAB.L('2','f',t)=0.131;
THETAB.L('2','d',t)= 0.156;
THETAB.L('3','f',t)=0.131;
THETAB.L('3','d',t)= 0.155;
THETAH.L('1','f',t)= 0.301;
THETAH.L('1','d',t)= 0.343;
THETAH.L('2','f',t)= 0.203;
THETAH.L('2','d',t)= 0.233;
THETAH.L('3','f',t)= 0.204;
THETAH.L('3','d',t)= 0.233;
THETAH.L('4','f',t)= 0.205;
THETAH.L('4','d',t)= 0.233;
THETAPT.L('f',t)=0.027;
THETAPT.L('d',t)=0.200;
THETAST.L('f',t)=0.031;
THETAST.L('d',t)=0.240;
THETABT.L('f',t)=0.222;
THETABT.L('d',t)=0.705;
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GAMMAP.L('1','f',t)= 0.199;
GAMMAP.L('1','d',t)= 0.191;
GAMMAP.L('2','f',t)=0.118;
GAMMAP.L('2','d',t)= 0.128;
GAMMAP.L('3','f',t)=0.091;
GAMMAP.L('3','d',t)= 0.087;
GAMMAP.L('4','f',t)= 0.065;
GAMMAP.L('4','d',t)= 0.062;
GAMMAP.L('5','f',t)= 0.054;
GAMMAP.L('5','d',t)=0.051;
GAMMAP.L('6','f',t)=0.026;
GAMMAP.L('6','d',t)=0.025;
GAMMAS.L('1','f',t)=0.141;
GAMMAS.L('1','d',t)= 0.139;
GAMMAS.L('2','f',t)=0.101;
GAMMAS.L('2','d',t)=0.099;
GAMMAS.L('3','f',t)=0.101;
GAMMAS.L('3','d',t)=0.099;
GAMMAB.L('1','f',t)=0.111;
GAMMAB.L('1','d',t)=0.108;
GAMMAB.L('2','f',t)=0.111;
GAMMAB.L('2','d',t)=0.108;
GAMMAB.L('3','f',t)=0.111;
GAMMAB.L('3','d',t)= 0.107;
GAMMAH.L('1','f',t)= 0.301;
GAMMAH.L('1','d',t)= 0.352;
GAMMAH.L('2','f',t)= 0.304;
GAMMAH.L('2','d',t)= 0.357;
GAMMAH.L('3','f',t)= 0.305;
GAMMAH.L('3','d',t)= 0.357;
GAMMAH.L('4','f',t)= 0.307;
GAMMAH.L('4','d',t)= 0.357;
E.L('p',t)= 310123.204;
E.L('s',t)= 104164.534;
E.L('b',t)= 55061.282;
E.L('h',t)= 20598.475;
EF.L('p',t)= 107112.982;
EF.L('s',t)= 42012.690;
EF.L('b',t)= 26670.266;
EF.L('h',t)= 15189.159;
ED.L('p',t)= 203010.222;
ED.L('s',t)= 62151.845;
ED.L('b',t)= 28391.016;
ED.L('h',t)= 5409.317;
EP.L('1','f',t)= 21768.500;
EP.L('1','d',t)=41659.459;
EP.L('2','f',t)= 19102.289;
EP.L('2','d',t)= 36948.949;
EP.L('3','f',t)= 17915.616;
EP.L('3','d',t)= 33937.889;
EP.L('4','f',t)= 16856.561;
EP.L('4','d',t)= 31769.484;
EP.L('5','f',t)= 16179.519;
EP.L('5','d',t)= 30271.789;
EP.L('6','f',t)= 15290.498;
EP.L('6','d',t)= 28422.652;
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ES.L('1','f',t)= 16111.201;
ES.L('1','d',t)= 24378.448;
ES.L('2','f',t)= 13553.835;
ES.L('2','d',t)= 19948.104;
ES.L('3','f',t)= 12347.654;
ES.L('3','d',t)= 17825.292;
EB.L('1','f',t)= 10853.083;
EB.L('1','d',t)= 11999.134;
EB.L('2','f',t)= 8526.681;
EB.L('2','d',t)= 8965.843;
EB.L('3','f',t)= 7290.503;
EB.L('3','d',t)= 7426.038;
EH.L('1','f',t)= 5755.095;
EH.L('1','d',t)= 2251.559;
EH.L('2','f',t)= 4159.303;
EH.L('2','d',t)= 1481.887;
EH.L('3','f',t)= 3049.534;
EH.L('3','d',t)= 1000.377;
EH.L('4','f',t)= 2225.227;
EH.L('4','d',t)= 675.494;

3) sensitivity analysis

The set of elasticities of dropout and repetition rates according to different assumptions in the four scenarios, computing the formula $\varepsilon_{ijk} = -\rho_{ijk} \ \alpha_{ijk}$, are:

scenario aL

rho/alpha	0.6	0.7
0.1	0.06	
0.2		0.14

scenario aH

rho/alpha	0.6	0.7
0.2	0.12	
0.9		0.63

scenario bL

rho/alpha	0.3	0.9
0.1	0.03	
0.2		0.18

scenario bH

rho/alpha	0.3	0.9
0.2	0.06	
0.9		0.81