

MPIA Network Session Paper

Optimal Policy Design for MDG Achievement: The Peruvian Case

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*A paper presented during the 5th PEP Research Network General Meeting,
June 18-22, 2006, Addis Ababa, Ethiopia.*

Optimal Policy Design for MDG Achievement: The Peruvian Case

RESEARCH PROPOSAL

Presented to PEP Network

(Revised version)

By

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February 8th, 2006

Abstract

This project's main objective is to provide a comprehensive tool for policy design aimed at achieving the first five MDGs. For this, we propose a systemic approach in order to capture the existence of interrelations and synergies between MDG indicators and potential policy interventions. In particular, our project will focus on two research questions. First, the formalization of feed-backs between MDG achievement and income generation potential; i.e. the connection between improvements in schooling, the accumulation of human capital and overall economic growth. In this way, improvements in specific MDG indicators will not only be viewed as a reduction in current overall poverty, but also as a means to accumulate the necessary resources for future generations to be able to permanently overcome this phenomenon. On the other hand, and related to the implementation of poverty reduction policies, the second research question focuses on the need to explicitly account for a loss function reflecting policymakers' preferences in order to address the issue of policy design from an optimality standpoint.

1. Main research questions and core research objectives

This project's main objective is to provide a comprehensive tool for social policy design aimed at achieving the first five Millennium Development Goals (MDGs) in an specific country setting. Due to the existence of strong interrelations and synergies between MDG indicators and potential policy interventions, policy design based on a cost-effectiveness analysis must be done from a systemic perspective. If we address the impact of different interventions considering that actions taken to achieve one MDG can have positive spill-over effects onto other indicators, it will be possible to estimate an optimal portfolio of interventions that should allow the policy maker or social planner to reach MDGs at a minimum cost.

When considering the above, there are two crucial elements that constitute the specific research questions of this project: (i) what are the main interrelations between MDG indicators that should be accounted for in order to guarantee a systemic approach to MDG achievement?; (ii) how should we model social planner's preferences and budget constraint in order to estimate an optimal portfolio of policy interventions?

2. Knowledge gaps and scientific contribution of the research

The wide range of aspects involved in MDGs, reflects the shift towards a broadened concept of poverty, and the fact that all these issues must be taken care of simultaneously, points out the relevance of promoting a comprehensive approach and a coordinated strategy for reducing poverty around the world.

Despite the above, MDG assessment has been usually conducted on a sectorial basis, estimating the future path of each indicator based only on its past evolution, or in structural models that include only a limited set of determinants, typically taking other MDG indicators as exogenous. Thus MDG prediction and costing can be biased because of the failure to consider the interactions among policy interventions and indicators.

One important effort aimed at a systemic assessment of MDG achievement, with a special emphasis on the identification and costing of specific policy interventions, can be found in Castro, *et al.* (2005). This model specifically addresses the possibility of identifying the optimal set of interventions that should allow MDG achievement at a minimum cost, and was applied using socio-economic data from Guatemala. Despite having explicitly considered the existence of positive spill-overs from education to health and mortality indicators, this model still lacks a connection between improvements in human capital formation (through the access to better education) and overall economic growth, the latter being exogenously driven.

On the other hand, and following the tradition of Computable General Equilibrium (CGE) models which already have been used to assess the impact of trade reform on poverty and inequality (see, for example, Decaluwé, *et al.* (1999)), we can identify another significant contribution in Lofgren and Diaz-Bonilla (2005). This analysis, which uses a CGE approach to capture the main interrelations between MDG achievement and macroeconomic performance, still lacks, however, an explicit consideration of the set of policy options available to the planner from an optimality standpoint. Moreover, it only proposes the existence of a limited set of interrelations between MDG indicators, and assesses the impact of a very broad set of policy options (via expansions in government consumption) that faces the risk of neglecting the role of specific (and probably highly cost-effective) social programmes.

Taking the above into consideration, and following the two research questions specified in the previous section, this project aims at addressing the issue of MDG achievement by combining and extending the novel contributions of the two approaches just described. Our attempt to answer the first question will necessarily imply an extension regarding the connection between improvements in schooling and health, the accumulation of human capital and overall economic growth. In other words, improvements in specific MDG indicators will not only be viewed as a reduction in current overall poverty, but also as a means to accumulate the necessary resources for future generations to be able to

permanently overcome this phenomenon (or state). This can be done by explicitly allowing a feed-back from MDG achievement to long run income generation potential: faster economic growth should foster MDG achievement, while the latter should also be allowed to act as a means to sustain and enhance the former.

Given a complete set of contemporaneous and future interrelations and feed-backs, we can then address the second extension proposed in this project: in which way should the social planner intervene today and towards year 2015 in order to foster MDG achievement and exploit these interrelations and feedbacks to guarantee that these improvements will not only be temporary. Obviously, and as proposed in the previous section, this second research question must be addressed from an optimality standpoint and requires an explicit consideration of the social planner's preferences and intertemporal budget constraint.

3. Policy relevance

MDGs must be viewed as a first step towards a consensus regarding the minimum set of arguments that a social planner's loss function must include. They have contributed to the debate regarding the multidimensional aspects of poverty and, in terms of policy analysis and design, made explicit the need of a systemic (or general equilibrium) approach.

Peru is a middle income developing country (per capita national income of current US\$2,360 in 2004) with a high degree of income inequality (estimated Gini coefficient of 0.5 in 2004) and social exclusion, and with pervasive difficulties to sustain high economic growth rates in the medium run. Therefore, national poverty incidence has remained around 50% of the population for the last two decades. Extreme poverty seems to have fallen from 25% to 20% from 1990, due to increased coverage of social policies and poverty alleviation programs. Yet this trend falls short of the one needed to achieve the MDG goal to cut poverty by half from 1990 to 2015. Quantitative analysis undertaken before (Beltran *et. al.*, 2004) indicated that a combination of active redistribution policies

and higher rates of economic growth would be needed for achieving the MDG of poverty reduction.

Increases in basic education coverage have made possible near universal enrolment in primary school, with little gender bias, but with remaining problems for minimum quality standards and completion at normative age. Some health indicators such as infant mortality rates are showing progress toward MDG achievement, but deficits in calorie-intake and high maternal mortality are problematic areas. Finally, access to water and sanitation has increased little in the last fifteen years. Stronger policy action and more resources would be needed to boost Peru's chances to achieve MDGs in 2015. Beltran *et al.* (2004) has estimated that in a 5% economic growth scenario for the next ten years, the government still would need an annual amount equivalent to 1.4% of GDP in additional resources for specific social and redistribution policies to improve the chances to achieve the first 5 MDGs. Yet our model approach in that paper lacked the two main improvements proposed in this research to better estimate the related fiscal costs and identify the priority policy actions.

This project has an immediate policy relevance since it proposes building an integrated model that explicitly accounts for the main interrelations and feed-backs among MDG indicators. In particular, it addresses policy design considering the role of a social planner that seeks to maximize welfare facing a budget constraint and a set of restrictions (given by the integrated system) regarding the impact of its policy instruments.

As in Castro, *et al.* (2005), the model can be used to simulate the effects of different policy interventions in order to answer questions such as:

- What are the specific policy tools that must be used (and their optimal path through time) in order to guarantee MDG achievement at a minimum cost?
- How large is this minimum cost considering fiscal constraints?

- What is the maximum attainable improvement in terms of MDG achievement (and the path exhibited by MDG indicators) given current and future budgetary constraints?
- And, particularly important considering our proposed research questions: how does the answer to all the above change if we allow for a more lucid (as opposed to myopic) planner by: (i) broadening the set of available interrelations and feed-backs among indicators; and (ii) defining a set of specific preferences regarding MDG achievement.

Simulations related to this last issue can prove particularly relevant for policy design and coordination at the sectorial level. In particular, it will be possible to compare improvements and total budgetary needs under different scenarios referred to the degree of coordination and knowledge regarding the existence of synergies among indicators.

For example, we can expect larger costs if we assume that sectorial planners are aware of synergies but fail to coordinate; i.e. they design their policies with no specific knowledge about the policy interventions and preferences of other sectorial planners. This can be done by simulating the entire system with preferences defined only to meet the targets for a specific subset of MDG indicators. Obviously, even larger costs are expected if sectorial planners are both unaware of synergies and fail to coordinate. Costs and improvements under this scenario can be estimated by shutting off interactions and synergies and simulating the system with preferences defined to meet only a subset of targets.

Total budgetary needs and improvements associated to each scenario can then be compared in order to explicitly account for the benefits of coordination and “awareness” about the existence of synergies. The design of an incentives programme aimed at fostering coordination among different policy actors relies on this information which, in fact, proxies the social value of coordination. As such, total incentives seeking coordination should not exceed this value.

4. Methodology

Extensions and research questions referred in the previous sections will be implemented using Peru as a case study. We propose a methodology divided into two stages.

The first stage seeks to extend and update the work already conducted in Beltrán, *et al.* (2004), and heavily relies on the use of econometric techniques to identify the set of determinants that best explains the behaviour of each of the indicators related to the first five MDGs. In particular, micro-econometric analysis can provide useful information regarding the significance and marginal impact of a proposed set of determinants on each of the indicators under analysis. Moreover, the functional forms relating determinants and indicators can also be provided by these estimations, and will depend on the econometric technique deemed as the most appropriate considering the nature of analyzed phenomena and the availability of data.

Since our interest focuses on a set of indicators built to describe the proportion of individuals (from the total population) that exhibit certain qualitative characteristics (MDG indicators), our analysis will mainly rely on the class of models designed to explain the behavior of a discrete dependent variable; in particular, those designed to model a binary choice (see Appendix 2 for a more detailed description).

This first stage also implies exploring potential spill-overs and feed-backs among analysed indicators and, in particular, between schooling, human capital formation and economic growth. Regarding this issue, we will rely on reduced form relationships of the class proposed in growth accounting models with an explicit role for human capital built, for example, adjusting the labour force using the average years of schooling (see Barro and Lee (2000) and Carranza *et al.* (2003) for an application to Peru). In this way, we will be able to link MDG achievement with growth and income generation potential (see Appendix 2 for a more detailed description).

The second stage, on the other hand, involves integrating and simulating the model. Given the set of interactions proposed and validated through the micro-econometric analysis, we can assume that the planner seeks MDG achievement given a budget constraint. Therefore, this second stage directly addresses the second research question proposed in this project (see Appendix 2 for a more detailed description).

In particular, we propose a series of simulations considering different scenarios for the planner's preferences and sources of financing for fiscal effort. Regarding planner's preferences, a critical issue is the parametrization of her loss function. Given the commitment regarding MDG achievement, an obvious candidate for the minimum set of arguments to be included in this function are the gaps between MDG indicators and their targets, with the requirement that these targets are achieved by year 2015. Two additional elements remain to be discussed and lie at the core of our second research question.

First, what should be the functional form relating these gaps and shall we allow for less than perfect substitutability between MDGs. For example, we can rely on the class of non-linear functions that will reflect the fact that one additional unit of improvement over an indicator that is close to its target will yields less "utility" than a unit of improvement over and indicator that still remains far from its target (i.e., by allowing the existence of a diminishing marginal utility over the proportion of the gap that is closed, where the latter can be regarded as a "good" for the planner).

On the other hand, another element to consider is the possibility of extending the set of arguments in the policymaker's loss function in order to allow for a planning horizon that spans beyond year 2015. In fact, MDGs have provided not only a set of meaningful arguments for a planner's loss function, but have also set an explicit time horizon for policy design and the evaluation of its outcomes. However, and as already mentioned in Section 2, a relevant question is what can be done today to ensure that these outcomes exhibit a permanent nature. Thus, one possible candidate for an extended loss function is a measure of the potential for income generation. Obviously, this extension is closely

linked to our first research question and, in particular, to the achievement of those MDGs that contribute to enhance economic growth and improve income distribution.

Finally, and regarding the methodology for the exercise that will address the issues discussed above, we propose the identification of exogenous policy variables among the set of determinants validated via the econometric analysis, and the numerical simulation of shocks over these variables so as to minimize the proposed loss function for a given budget constraint.

5. Data requirements and sources

Main databases needed to undertake the micro-econometric modeling and costing exercise are: (i) nationwide household surveys which gather simultaneously information on income and expenditure levels, schooling, and access to infrastructure and public programs at the household and individual levels; (ii) nationwide demographic and health surveys which capture detailed information on health status and practices together with other household and individual information; and (iii) detailed administrative records on costs and benefits distribution of main education, health, nutrition, water and sanitation programs.

Peru's National Statistical Institute conducts household surveys representative at the national and regional levels every year and databases are available through its web page. Likewise, it carries health and demographic surveys every five years (the latest one being from 2004). Finally, administrative records on program costs can be retrieved from the public sector's integrated system of financial management and detailed budgets from health and education ministries.

Macroeconomic data required for the growth accounting exercise and government budget constraint will be obtained from Carranza *et al.* (2003) and the Ministry of Finance. In particular, historic TFP, capital and labour force growth rates together with the technology parameter (θ), will be those estimated in Carranza *et al.* (2003):

$\gamma_A = 0.0106$, $\gamma_K = 0.0338$, $\gamma_L = 0.0290$, $\theta = 0.44$. Data referred to fiscal debt and government recurrent expenditure and total revenues will be obtained from the public sector's integrated system of financial management and the Multiyear Macroeconomic Framework (2006-2008). This document analyses and contains medium run forecasts for Peru's main macroeconomic variables, and will aid in the specification of different scenarios regarding the future path of the main components of the proposed budget constraint.

6. Dissemination strategy

The consultation and dissemination strategy for this project will take advantage of and rely intensively on the solid and representative network on MDG assessment built in Peru among national and regional policy makers, political parties, civil society groups, multilateral organizations, bilateral donors and academia. This network was an explicit outcome obtained through the preparation of the Peruvian report on progress to achieve MDGs in 2004. Our research team participated throughout all this effort as a technical support team for the debates and prepared Beltrán, *et al.* (2004) as a background paper and a first effort to simulate and cost MDG achievement by 2015.

We plan to have two seminars with this network, one at the beginning of the project to receive feedback on our proposal, and one at the end of the project to disseminate and discuss its results and policy implications. We have kept contact with Finance Ministry and local UNDP officials and discussed already the relevance of our project for policy planning and reform proposals.

Our university also offers the adequate environment for further dissemination of our project's results through conferences and seminars during 2006. Likewise, we will publish the project's results as a working paper through our editorial unit and distribute it to key policy makers and leaders of public opinion in Peru and Latin America. We will also prepare press releases summarizing the key messages from our project and have interviews with newspapers and specialized magazines.

7. Short list of key references

Barro, Robert and Jong Wha Lee (2000), *International Data on Educational Attainment: Updates and Implications*, NBER Working Paper 7911.

Beltrán, A., J. F. Castro, E. Vásquez and G. Yamada (2004), *Objetivos de desarrollo del milenio en el Perú: alcanzando las metas. (MDGs in Peru: Reaching the Goals)*, UNDP and Centro de Investigación de la Universidad del Pacífico (CIUP), Lima, December 2004.

Carranza, E, Jorge Fernández-Baca and Eduardo Morón (2003), *Peru: Markets, Government and the Causes of Growth*, Centro de Investigación de la Universidad del Pacífico (CIUP), Lima.

Castro, J. F., Beltrán, A., E. Vásquez and G. Yamada (2005), *A Systemic Assessment of MDG Achievement: The Case of Guatemala*, Centro de Investigación de la Universidad del Pacífico, Lima, September 2005.

Decaluwé, B., A. Patry, L. Savard and E. Thorbecke (1999), *Poverty Analysis Within a General Equilibrium Framework*, Working Paper 9909, CRÉFA.

ECLAC-IPEA-UNDP (2002), *Meeting the Millennium Poverty Reduction Targets in Latin America and the Caribbean*.

Lofgren, H. y Diaz-Bonilla, C. (2005), *An Ethiopian Strategy for Achieving the Millennium Development Goals: Simulations with the MAMS model*, DECGP, World Bank.

Obeng, Stephen (2002), *Ethnicity and Infant Mortality in Sub-Saharan Africa: The Case of Ghana*, Discussion Paper No. 02-10, Population Studies Centre, University of Western Ontario.

Vos, Rob, José Cuesta, Mauricio León, Ruth Lucio, and José Rosero (2004) “Health”, in: World Bank and Inter-American Development Bank (2004) *Ecuador: Creating Fiscal Space for Poverty Reduction. A Fiscal Management and Public Expenditure Review*, Volume II, Report No. 28911-EC, Washington D.C.: The World Bank and IADB.

Wooldridge, Jeffrey (2002), *Econometric Analysis of Cross Section and Panel Data*, The MIT Press, Cambridge, Massachusetts.

8. List of team members' prior training and experience in the issues and techniques involved.

Team members' relevant experience is summarized in the following table.

<p>Arlette Beltrán Age: 41 Sex: Female</p>	<ul style="list-style-type: none"> - Professor of Econometrics and Project Appraisal at Universidad del Pacifico. - Senior Researcher in the project: "Overcoming Operational Barriers to the Provision of Services for Safe Motherhood in Five Low-Income Departments in Peru: Costing Study". Policy Project - USAID, 2003 - Team member in the project: "Objetivos de Desarrollo del Milenio en el Perú: Alcanzando las Metas", UNDP-CIUP, 2004. - Team member in the project: "A Systemic Assessment of MDG Achievement: The Case of Guatemala", IADB-SEGEPLAN (Guatemala), 2005. - Team member in the project: "Second Phase of the Support Program for the Health Sector Reform (PARSALUD)", IADB, WB, 2005.
<p>Juan F. Castro Age: 30 Sex: Male</p>	<ul style="list-style-type: none"> - Professor of Econometrics and Macroeconomics at Universidad del Pacifico. - Team member in the project: "Objetivos de Desarrollo del Milenio en el Perú: Alcanzando las Metas", UNDP-CIUP, 2004. - Team member in the project: "A Systemic Assessment of MDG Achievement: The Case of Guatemala", IADB-SEGEPLAN (Guatemala), 2005. - Team member in the project: "Assessing Development Strategies to Achieve the Millennium Development Goals in Latin America", UNDP-RBLAC, World Bank, ECLAC, IADB, 2005-2006. - General equilibrium modeling to assess monetary policy issues. Working paper: "Assessing Vulnerability in Partially Dollarized Economies" (joint with Eduardo Morón and Diego Winkelried, 2004).

<p>María A. Cárdenas Age: 25 Sex: Female</p>	<ul style="list-style-type: none"> - Research assistant for the project: “A Systemic Assessment of MDG Achievement: The Case of Guatemala”, IADB-SEGEPLAN (Guatemala), 2005. - Working paper: “Acceso, eficiencia y equidad en el sistema educativo peruano: Un análisis de los indicadores de la Encuesta de Hogares y el Censo Escolar” (joint with Jaime Saavedra, 2002). - Working paper: “Determinantes conjuntos de la educación y el trabajo en los menores: un análisis para el caso peruano en el año 2000” (joint with Fabricio Neciosup, 2001).
<p>Gustavo Yamada Age: 42 Sex: Male</p>	<ul style="list-style-type: none"> - Professor of Microeconomics and Macroeconomics at Universidad del Pacifico - Team member in the project: “Objetivos de Desarrollo del Milenio en el Perú: Alcanzando las Metas”, UNDP-CIUP, 2004. - Team member in the project: “A Systemic Assessment of MDG Achievement: The Case of Guatemala”, IADB-SEGEPLAN (Guatemala), 2005. - Team member in the project: “Assessing Development Strategies to Achieve the Millennium Development Goals in Latin America”, UNDP-RBLAC, World Bank, ECLAC, IADB, 2005-2006.

9. Expected capacity building

Given the nature of our project, team member’s research capacities will be significantly enhanced via direct interaction with the Modeling and Policy Impact Analysis (MPIA) research group. In particular, capacity building will focus on the following areas:

- The use of econometric techniques to address the significance and impact of policy interventions on social indicators.
- Economy-wide analysis of the impact of specific policy interventions on social indicators, poverty (on its monetary dimension), and income distribution. In

particular, the application of models to address the issue of poverty and the role of policy design aimed at alleviating this phenomenon.

- How to address the issue of policy design from an optimality standpoint with an explicit role for a social planner. In particular, how to explicitly account for the existence of market failures that justify the role of a planner in a general equilibrium framework.
- The multidimensional (and intertemporal) nature of poverty and the parametrization of a social planner loss function.
- Methods for numerical simulation addressing the issue of intertemporal choice.

The proposed tasks that each team member will carry out are summarized in the following table.

Arlette Beltrán	- Micro-econometric modelling and discussion of results: health indicators.
Juan F. Castro	- Micro-econometric modelling and discussion of results: nutrition indicators. - General support for micro-econometric modelling.
María A. Cárdenas	- Micro-econometric modelling and discussion of results: education indicators.
Gustavo Yamada	- Model integration and simulation. - Models connecting human capital with economic growth, poverty and income distribution.

10. Any ethical, social, gender or environmental issues or risks which should be noted.

None.

11. List of past, current or pending projects in related areas involving team members

(name of funding institution, title of project, list of team members involved)

Team members	Project title	Year	Funding Institutions
Arlette Beltrán, Juan F. Castro, Gustavo Yamada, Enrique Vasquez (with the support of María A. Cárdenas)	Objetivos de Desarrollo del Milenio en el Perú: Alcanzando las Metas (<i>MDGs in Peru: Reaching the Goals</i>)	2004	United Nations Development Program (UNDP)
	A Systemic Assessment of MDG Achievement: The Case of Guatemala	2005	Inter American Development Bank (IADB)
Juan F. Castro and Gustavo Yamada	Assessing Development Strategies to Achieve the Millennium Development Goals in Latin America	2005-2006	UNDP, World Bank, Economic Commission for Latin America and the Caribbean (ECLAC), IADB.
Gustavo Yamada (with the support of María A. Cárdenas)	Impacto en el nivel de vida de la población del desempeño macroeconómico en el Perú 2001-04 (<i>Macroeconomic performance's impact on living standards</i>)	2005	Finance Ministry of Peru and IADB

Appendix 1

About this revised proposal

Where does Peru stand regarding MDG achievement?

We have included a brief description of Peru's economic and social trends related to MDG achievement (see pgs. 4-5)

More details on the technical aspects of the proposal.

We have discussed all technical details in Appendix 2.

Macro data requirements.

We have included a brief discussion regarding data requirements for the macro module in accordance with the specifications presented in Appendix 2 (see pgs. 9-10)

Experimented member on macroeconomic modeling.

Project leader Gustavo Yamada and team member Juan F. Castro are not only professors of Macroeconomics at Universidad del Pacifico, but are currently involved in a regional project (*Assessing Development Strategies to Achieve the Millennium Development Goals in Latin America*) which involves extensive macro modeling within a CGE framework. Juan F. Castro has also prepared several papers which analyse monetary policy issues within a general equilibrium macroeconomic framework.

Intertemporal dimension of the study.

Appendix 2 also formalises the general form of the optimization problem with an explicit time dimension for a finite planning horizon (up to 2015).

Feasibility of the study.

Previous experience regarding micro-econometric modeling of the determinants of each MDG indicator will facilitate the first stage of our study. In this way, we will be able to focus on the two main extensions proposed: (i) macro-micro linkages via human capital accumulation;

and (ii) the simulation and costing exercise with an explicit loss function and budget constraint for the policymaker.

Team members.

In order to ensure the appropriate gender-experience balance of our team, we have included María A. Cárdenas. María is a young B.A. in economics and a promising research assistant for the Social Policy Area of our research centre. She has actively contributed in several of our past research efforts related to these topics and we believe including her as part of our team will enhance her research capabilities and will constitute an invaluable experience. We are not longer considering Enrique Vasquez's contributions for this project.

Appendix 2

Micro-econometric modeling, micro-macro linkages and model simulation

1. Main features of the micro-econometric modeling techniques

As described in Section 4, our interest focuses on a set of indicators built to describe the proportion of individuals (from the total population) that exhibit certain qualitative characteristic (MDG indicators). Moreover, and since the aim of our analysis is to infer the behavior of this proportion through time, one would expect that the preferred database should explicitly include a time dimension. However, the availability of information typically imposes a trade-off: we usually encounter too few observations for a time series analysis, while household survey data (which substantially increases the number of observations and the variability of covariates through space) typically lack a panel structure. Thus, and if the scarcity of time series information imposes almost no degrees of freedom for estimation, the only practical solution is to rely on cross-sectional household surveys. Obviously, this implies assuming that behavioral patterns captured in year 0 cross-section will not vary significantly through time.

Under this scenario, our estimate of the mean of the dependant variable conditioned on set of covariates is the probability of occurrence of the event under analysis, and the specific functional form for this probability will be given by the type of distribution assumed for the error term. For example, if we assume a logistic distribution and define the vector containing the set of determinants associated to individual (i) as X_i , the above will imply:

$$E[y_i | X_i; \theta] = \Pr[y_i = 1 | X_i; \theta] = \frac{\exp(X_i' \theta)}{1 + \exp(X_i' \theta)} \quad (1.)$$

The parameters involved (θ) can be estimated with cross-sectional household survey data, and equation (1) can be used to infer the probability that an individual with characteristics X_i will exhibit the discrete characteristic identified in the dependant variable (y_i).

In order to infer the behavior of MDG indicators through time, and under the assumption that behavioral patterns will remain relatively constant in this dimension, we can rely on the estimated values of θ and the functional form described in (5) to predict the probability that an average individual will exhibit the characteristic under study in period (t). The probability associated to this “average individual” can be, in turn, directly associated to the proportion of individuals who exhibit the characteristic. For this, we need to evaluate (1) using the mean values (across space) of the set of determinants in period (t) (\bar{X}_t). In this way, and for a given set of these mean values, we will be able to predict the indicator’s value in period (t).

$$\text{MDG}_{i,t} = \Pr[y_t = 1 | \bar{X}_t; \theta] = \frac{\exp(\bar{X}_t' \theta)}{1 + \exp(\bar{X}_t' \theta)} \quad (2.)$$

The behavioural assumptions that inspire this class of binary choice models are particularly appropriate to capture the cost-benefit analysis that lies behind results regarding education indicators. In fact, education can be viewed as an investment that depends on the costs and benefits associated with enrollment. Costs can be direct (uniforms, books, fees, etc.) or indirect (the opportunity cost –in terms of forgone household income- of sending the child to school), while benefits are mainly related to the accumulation of human capital and its impact on future earnings. Thus, this class of models will be used to model MDG indicators related to education. In fact, enrollment at a particular age in a particular grade can be viewed as the discrete realization of an unobserved latent variable that reflects the net utility associated to schooling. Thus, the probability of observing enrollment corresponds to the probability of a positive net utility which, in turn, depends on a set of determinants linked to household conditions and supply side factors.

Phenomena related to health indicators, on the other hand, will be modelled via duration analysis. Intuitively, the occurrence of death among children within a particular age interval should depend on the time elapsed until the event (death) takes place. In other words, the probability of dying after a number of months should be regarded as a conditional

probability, conditioned on having survived until then. Given this, hazard functions which stem from duration analysis prove to be the most appropriate tool to deal with this type of phenomena, since they are specifically built to approximate the probability of exiting a particular state in a particular time, given that the subject has survived until that time¹. Moreover, and as discussed in Vos, *et al.* (2004), relying on binary response models (probit or logit estimations) will tend to yield biased estimates of the impact of determinants since the application of this technique will require depurating the sample to consider only those cases where infants have reached age one or age five, in order to determine survival or non-survival. Duration analysis, on the other hand, will allow us to consider the entire sample of children within the relevant age interval.

Thus, our analysis will focus on determining how the conditional probability of death (given survival until a particular time) changes for a given set of socioeconomic characteristics. Given this, we need to condition our hazard function on a specific set of covariates. Following Wooldridge (2002) notation, let $T \geq 0$ denote a random continuous variable defined as the duration, t denote a particular value of T , and $F(\cdot|x)$, $f(\cdot|x)$ its cdf and density, respectively, conditional on the vector of covariates (x). For the purpose of our analysis, T will denote the time at which the subject leaves the initial state, in particular, the month at which the child dies. Given this, the hazard function will approximate the probability of dying in t , given survival up until that time, and is defined as:

$$\lambda(t; x) = \frac{f(t|x)}{1 - F(t|x)} \quad (3.)$$

In order to give an specific functional form to this hazard function, we relied on the class of models known as proportional hazard models. A proportional hazard can be written as:

$$\lambda(t; x) = \kappa(x)\lambda_0(t) \quad (4.)$$

¹ Several studies have relied on duration analysis to account for infant and child mortality. See, for example, Obeng (2002) or Vos, *et al.* (2004) for a more recent survey on the topic.

where $\lambda_0(t)$ is called the baseline hazard and is common to all units in the population. Thus, individual hazard functions will differ proportionally according to $\kappa(x)$ which, in turn, is typically parameterized as $\kappa(x) = \exp(x\beta)$. Since our analysis will focus on how the covariates shift the hazard function, the estimation method used will be based on the Cox Proportional Hazard Model (CPH), which proposes a partial maximum likelihood estimator of β that does not require estimating the baseline hazard.

2. Micro-macro linkages

In order to account for the impact of economic growth on household's income and poverty (MDG indicator 1), we will rely on the macro scenarios model proposed in ECLAC-IPEA-UNDP (2002). According to their specification, the per capita household expenditure of individual (h) (for a given rate of economic growth and percentage fall in the Gini coefficient) in period (T) can be expressed as:

$$y_{hT}^* = (1 + \beta)^T \left[(1 - \alpha)y_{h,0} + \alpha\bar{y}_0 \right] \quad (5.)$$

where β refers to the annual rate of (distribution-neutral) GDP growth, α is the percentage fall in the Gini coefficient, while $y_{h,0}$ and \bar{y}_0 refer to year 0 per capita household expenditure of individual (h) and the average per capita household expenditure, respectively.

With the above formula, and for a given annual rate of GDP growth and poverty line (ycrit), it would be possible to compute the percentage fall in the Gini coefficient required at the end of the planning period (T) in order to achieve the poverty target (TPov). That is, the value of α that guarantees that:

$$\left[\sum_{h=1}^{Pop_T} 1(y_{hT}^* < y_{crit}) \right] / Pop_T \leq TPov \quad (6.)$$

However, our intention is to extend previous models and instead of assuming a constant annual rate of GDP growth, allow this rate to vary according to the accumulation of human capital via achievements in those MDGs related to education. For this, we will rely on the typical formulation of a growth accounting exercise with an explicit role for human capital. For a production technology given by:

$$Y_t = A_t K_t^\theta (L_t H_t)^{(1-\theta)} \quad (7.)$$

annual GDP growth (for a given TFP, capital and labour force growth rate) can be expressed as:

$$\gamma_{Y,t} = \gamma_A + \theta \gamma_K + (1-\theta) [\gamma_L + \gamma_{H,t}] \quad (8.)$$

Thus, our intention is to allow GDP growth to vary via accelerations in H_t . As already mentioned, this variable will account for human capital formation and, following Barro and Lee (2000), will be given by:

$$H_t = \sum_{i=0}^3 N_i (h_{i,t}) \quad (9.)$$

where :

N_i = Number of years in each education level (none, primary, secondary, tertiary).

h_{it} = Proportion of the workforce (people with 15 or more years of age) with each education level.

In this way, we will be able to adjust the labour force using the average years of schooling, and this average will be a function of the achievements related to education indicators (MDG 2). In particular, and according to Barro and Lee's formulation, each h_{it} will be calculated as function of past and current enrolment rates in each education level, and these enrolment rates will be determined by the set of policy instruments and controls validated via the micro-econometric modeling exercise.

In this way, we propose to account for the positive spill-overs between schooling, human capital formation and economic growth: more education today will not only reflect upon MDG achievement on impact, but will also foster economic growth and, thus, help to ensure MDG achievement in the future and relax the fiscal burden of this effort.

3. The simulation exercise

As described in Section 4, the simulation exercise aims at determining which is the optimal combination of policy interventions required to maximize MDG achievement for a given budget constraint. For a general discussion, let us assume that we have targets for (m) indicators other than poverty incidence ($I_{jt}; j=1, \dots, m$) and have a total of (i) policy variables ($x_{it}; i=1, \dots, n$). Period (t) value for indicator j is given by: $I_{jt} = I_j [x_{it}, Y_t]$, where the specific form of the function $I_j [\square]$ will depend on the results of the micro-econometric modeling exercise.

Each period (t), the policymaker faces the following budget constraint:

$$\begin{aligned} B_t &= (1+r)B_{t-1} + G_t + \text{GMDG}_t - R_t \\ B_t - B_{t-1} &\leq \lambda Y_t \end{aligned} \tag{10.}$$

where:

B_t \equiv debt stock at period t.

r \equiv interest rate.

G_t \equiv period t total recurrent fiscal expenditure.

GMDG_t \equiv period t incremental fiscal expenditure devoted to MDG achievement.

R_t \equiv period t total fiscal revenues.

Y_t \equiv period t GDP.

Given year 0 debt stock, this budget constraint will be used to assess different scenarios regarding the path of recurrent fiscal expenditures and revenues such that, given the incremental expenditure devoted to MDG achievement, the current fiscal rule is satisfied.

This fiscal rule states that, each period, the total deficit should not be greater than 1% ($\lambda = 0.01$) of GDP.

Subject to functions $I_j[\square]$ and the budget constraint described above, we assume the policymaker seeks to minimize her loss function which, in turn, will depend on the distance between each target value (T_j) and the level attained by the indicator at the end of the planning period (I_{jT}). Given the condition that targets should be met by year 2015, we can assume a finite planning horizon ($t = 1, \dots, T$; $T = 10$) and a policymaker that, acting under perfect foresight, plans up to period T and seeks MDG achievement via a gradual increase in policy instruments subject to the condition that the fiscal rule is met each year.

Regarding the nature of policy variables, we propose to distinguish between those that imply a “once and for all” expenditure vs. those that imply a “recurrent” expenditure. The former will typically refer to the provision of infrastructure (e.g. water and sanitation) while the latter to the provision of specific services (e.g. health insurance, scholarships, etc.). Moreover, policy variables will be typically expressed as the proportion of the population with access to a particular type of infrastructure or service. Thus, and if we assume that we have n_1 policy variables linked to the provision of infrastructure and n_2 policy variables linked to the provision of services ($n_1 + n_2 = n$), annual costs related to policy interventions will be calculated following:

$$\begin{aligned} \text{GMDG}_{it} &= [(x_{it} - x_{i0})\text{Pop}_{it} - (x_{it-1} - x_{i0})\text{Pop}_{it-1}] \text{UC}_i; \quad i = 1, \dots, n_1 \\ \text{GMDG}_{it} &= [(x_{it} - x_{i0})\text{Pop}_{it}] \text{UC}_i; \quad i = 1, \dots, n_2 \end{aligned} \quad (11.)$$

where Pop_{it} and UC_i refer to the total population of potential beneficiaries and the unit cost of attending an additional beneficiary related to policy instrument (i), respectively.

Given all the above, the proposed optimization problem will have the general form:

Choose (x_{iT}, α) to

$$\text{Min LF}[\text{GAP}_1, \text{GAP}_j]; \quad j = 1, \dots, m$$

subject to:

MDG1:

$$1. \text{ GAP}_1 = \text{abs}(\text{Pov}_T - \text{TPov}) / \text{Pov}_T$$

$$2. \text{ Pov}_T = \left[\sum_{h=1}^{\text{Pop}_T} 1(y_{h,T}^* < \text{ycrit}) \right] / \text{Pop}_T$$

$$3. y_{h,T}^* = \prod_{t=1}^T (1 + \gamma_{Yt}) \left[(1 - \alpha)y_{h,0} + \alpha \bar{y}_0 \right]$$

$$4. \alpha_t = \alpha_{t-1} + \alpha / T; \quad t = 1, \dots, T; \quad \alpha_0 = 0$$

$$5. \text{ Pov}_t = \left[\sum_{h=1}^{\text{Pop}_t} 1(y_{h,t}^* < \text{ycrit}) \right] / \text{Pop}_t; \quad t = 1, \dots, T$$

$$6. y_{h,t}^* = \prod_{s=1}^t (1 + \gamma_{Ys}) \left[(1 - \alpha_t)y_{h,0} + \alpha_t \bar{y}_0 \right]; \quad t = 1, \dots, T$$

Rest of MDGs:

$$7. \text{ GAP}_j = \text{abs}(T_j - I_{jT}) / T_j; \quad j = 1, \dots, m$$

$$8. I_{jT} = I_j[x_{iT}, Y_T]; \quad j = 1, \dots, m; \quad i = 1, \dots, n$$

$$9. \gamma_i = (x_{iT} / x_{i0})^{1/T}; \quad i = 1, \dots, n$$

$$10. x_{it} = x_{i0}(\gamma_i)^t; \quad i = 1, \dots, n; \quad t = 1, \dots, T$$

$$11. I_{jt} = I_j[x_{it}, Y_t]; \quad j = 1, \dots, m; \quad i = 1, \dots, n; \quad t = 1, \dots, T$$

GDP Growth:

$$12. \gamma_{Y,t} = \gamma_A + \theta \gamma_K + (1 - \theta) [\gamma_L + \gamma_{H,t}]; \quad t = 1, \dots, T$$

$$13. Y_t = \gamma_{Yt} Y_{t-1}; \quad t = 1, \dots, T$$

$$14. H_t = \sum_{i=0}^3 N_i(h_{i,t}); \quad t = 1, \dots, T$$

$$15. h_{i,t} = F[I_{jt}]; \quad t = 1, \dots, T; \quad \forall j \text{ which refer to education indicators (enrolment rates)}$$

Costs and budget constraint:

$$16. \text{GMDG}_{it} = [(x_{it} - x_{i0})\text{Pop}_{it} - (x_{it-1} - x_{i0})\text{Pop}_{it-1}]UC_i; \quad i = 1, \dots, n1; t = 1, \dots, T$$

$$17. \text{GMDG}_{it} = [(x_{it} - x_{i0})\text{Pop}_{it}]UC_i; \quad i = 1, \dots, n2; t = 1, \dots, T$$

$$18. \text{RC}_t = \prod_{s=1}^t (1 + \gamma_{Y_s}) \sum_h \left[\alpha_t (\bar{y}_0 - y_{h,0}) \right] \quad \forall h \text{ where } \bar{y}_0 > y_{h,0}$$

$$19. \text{GMDG}_t = \sum_{i=1}^{n1} \text{GMDG}_{it} + \sum_{i=1}^{n2} \text{GMDG}_{it} + \text{RC}_t; \quad t = 1, \dots, T$$

$$20. B_t = (1+r)B_{t-1} + G_t + \text{GMDG}_t - R_T; \quad t = 1, \dots, T$$

$$21. B_t - B_{t-1} \leq \lambda Y_t; \quad t = 1, \dots, T$$