Analyzing policies for achieving the MDGs with MAMS

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Introduction

- MAMS (Maquette for MDG Simulations); a dynamic-recursive CGE (Computable General Equilibrium) Model.
- Initially developed for country-level MDG strategies: How should government and aid policies be designed to achieve the MDGs?
- Evolved into a general framework for country-level, *ex-ante*, medium-to-long-run development policy analysis, with emphasis on fiscal issues and MDG indicators.
- Different versions ranging from aggregated macro version to disaggregated MDG version.
- In addition to major non-monetary MDGs, MAMS covers monetary poverty, like other CGE models using two alternative approaches: representative household (RH) and microsimulation (MS).

Introduction

- As of May 2009, applications in 35 countries (18 in Latin America and the Caribbean; 8 in Sub-Saharan Africa; 5 in MENA; 4 in other Asia)

- Used for World Bank country analysis (including Country Economic Memoranda, Public Expenditure Reviews, Poverty Assessments), by teams in developing countries (in joint work with the UN).

- For info on MAMS and the work program around MAMS, visit: www.worldbank.org/mams

Outline

1. Issues in MDG strategy analysis
2. Model structure
3. Examples of scenarios
4. Dominican Republic: A MAMS-microsimulation application
5. Policy insights from country studies
6. Summary/Conclusions
- References and appendices at end provide more details.

1. Issues in MDG strategy analysis

□ MAMS is designed to consider the following aspects of MDG scenarios:

1. Role of non-government service providers

2. Demand-side conditions (incentives, infrastructure, incomes)

3. Role of economic growth

4. Macro consequences of increased government spending under different financing scenarios

5. Diminishing marginal returns (in terms of MDG indicators) to services and other determinants

6. Role of efficiency and input prices (e.g. wages) in determining unit service costs

2. Model Structure

□ MAMS may be described as an *extended*, dynamic-recursive computable general equilibrium (CGE) model designed for MDG analysis.

□ MAMS is coded in GAMS/Excel.

□ MAMS is complementary to and synthesizes results from *sector and econometric research on MDGs*.

□ Motivation behind the design of MAMS:

■ An economywide, flexible-price model is required.

■ Standard CGE models provide a good starting point.

■ But standard CGE approach must be complemented by a satisfactory representation of 'social sectors'.

Features Common to Most CGE Models

- Computable ➔ solvable numerically
- General ➔ economy-wide
- Equilibrium ➔
  - agents have found optimal solutions subject to constraints
  - quantities demanded = quantities supplied
  - macroeconomic account balance
- Producers use factors and intermediates as inputs.
- Imperfect transformability/substitutability in foreign trade.
- Dynamic-recursive ➔ the solution in any time period depends on current and past periods, not the future.
- A "real" model: only relative prices matter; no modeling of inflation.

Figure. Aggregate payments in MAMS
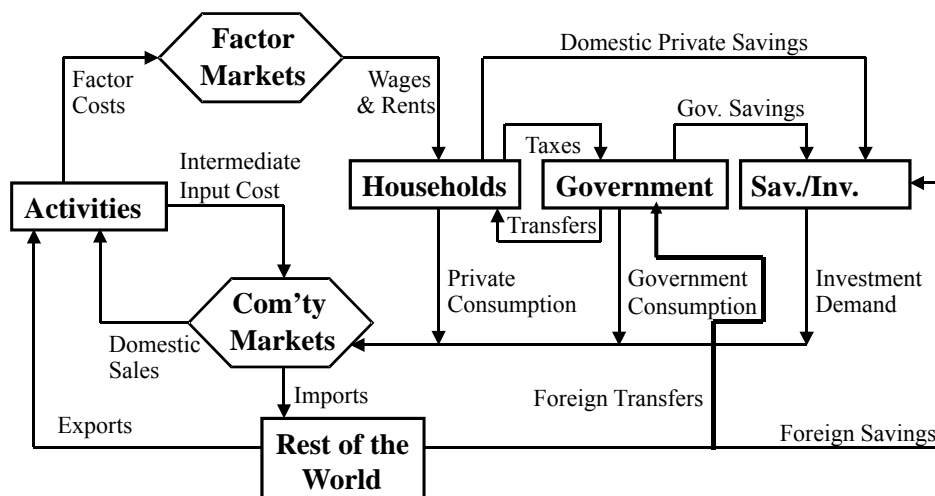
Government

- Government services are produced using labor, capital, and intermediates.
- Government spending is split into
  - Recurrent: consumption, transfers, interest
  - Capital (investment)
- Government demand (consumption and investment) is classified by function: social services (education, health, water-sanitation), infrastructure and "other government".
- Government spending is financed by taxes, domestic borrowing, foreign borrowing, and foreign grants.
- Model tracks government domestic and foreign debt stocks (including foreign debt relief) and related interest payments.

MDGs

- Most MAMS applications cover MDGs 1 (poverty), 2 (primary school completion), 4 (under-five mortality rate), 5 (maternal mortality rate), 7a (water access), and 7b (sanitation access).
- The main originality and extensions of MAMS compared to standard CGE models is the inclusion of (MDG- and/or education-related) *social services* and their impact on MDGs and other aspects of social and economic performance.
- Social services may be produced by the government and the private sector.

MDG "production"

- ❑ Each MDG "produced" by a combination of determinants (including government social services; see table) using a (reduced) functional form that permits:
  - ■ Imposition of limit (maximum or minimum)
  - ■ Replication of base-year values and elasticities
  - ■ Calibration to additional point (typically conditions at which the MDG in question is achieved).
  - ■ Diminishing marginal returns to the inputs
- ❑ Two-level function:
  1. Constant-elasticity function at the bottom: $Z = f(X)$
  2. Logistic function at the top: $MDG = g(Z)$; (see graph)

Determinants of MDG outcomes

MDG	Service per capita or student	Consumption per Capita	Wage incentives	Public infrastructure	Other MDGs
2–Primary schooling	X	X	X	X	4
4-Under-five mortality	X	X		X	7a,7b
5-Maternal mortality	X	X		X	7a,7b
7a-Water	X	X		X	
7b-Sanitation	X	X		X	

Logistic function
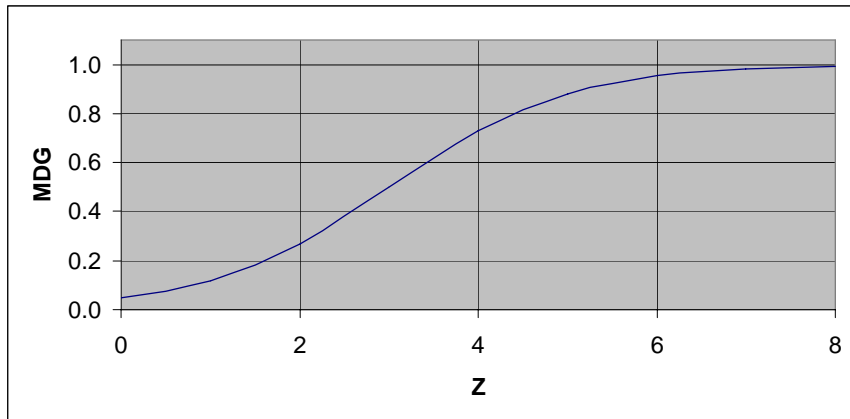
Education and labor

- Education is divided into three levels: primary, secondary, and tertiary.

- At each level, model generates the evolution of the number of students that are enrolled; pass, repeat or drop out from current grade; graduate from their current level; continue to next level; and, among those who exit, enter the labor force (in segment with same educational achievement).

- This evolution is determined by education "quality" at each level (services per student) and other determinants (private consumption, stock of infrastructure, and wage incentives).

- MDG 2 (net primary completion rate) computed as product of 1st grade entry rate and primary level pass rates for the relevant series of years.

Dynamics

- Updating of stocks of
  - factors (endogenous for different types of labor and capital, exogenous for other factors); and
  - population (with some age disaggregation; exogenous in most applications)
  - debt (domestic and foreign; both endogenous)
- TFP (Total Factor Productivity)
  - Endogenous part is a function of (i) economic openness; (ii) government infrastructure capital stocks.
  - Exogenous part captures what is not explained in model (institutions, new technologies, ….)
- GDP growth is determined by:
  - growth in economywide TFP (influenced by labor-force composition)
  - growth in factor employment (mostly endogenous)

Flexible modeling framework

- MAMS has a flexible disaggregation of production activities and commodities, factors, and households (GAMS facilitates)
- Data readily available for virtually any country for the MAMS minimum version: simple two-sector (government – private) framework for dynamic macro analysis.
- MAMS may include:
  - Wide range of taxes
  - NGO + private MDG/HD services
  - Special-case sectors (resource-based export, regulated utility)
- Special versions developed to deal with additional issues: demography, gender, and natural disasters.

Policy tools and indicators

- ☐ Key policy tools under government control:
  - ■ level and composition of government spending (by function);
  - ■ financing of government spending (taxes, domestic or foreign borrowing, foreign grants)
- ☐ Key performance indicators include the evolution of:
  - ■ Private and government consumption and investment, exports, imports, value-added, taxes; all indicators may be national totals or disaggregated
  - ■ Domestic and foreign debt stocks
  - ■ MDG indicators (poverty, non-poverty MDGs)
  - ■ Educational composition of labor force

Macro Closures

- ☐ Mechanisms for clearing (assuring that receipts = outlays) of:
  1. Balance of Payments – real exchange rate
  2. Savings-Investment Balance – private investment
  3. Government budget → next slide

Government Closures

- The selection of variable clearing the government budget is an important part of many scenarios. Common options:
  1. Domestic tax rates
  2. Domestic borrowing
  3. Foreign grants
  4. Foreign borrowing
  5. Scaling of government spending item(s)

Market-clearing variables for commodities and factors

- Commodities. Three categories:
  - Domestic output sold at home: prices
  - Exports: quantities demanded (or international demand function)
  - Imports: quantities supplied
- Factors. Two alternatives:
  1. exogenous unemployment: wage clears
  2. endogenous unemployment. Two regimes:
     a. unemployment above minimum rate: unemployment rate clears (influencing reservation and market wage)
     b. unemployment at minimum rate (= full employment): wage clears

Factor market with endogenous unemployment
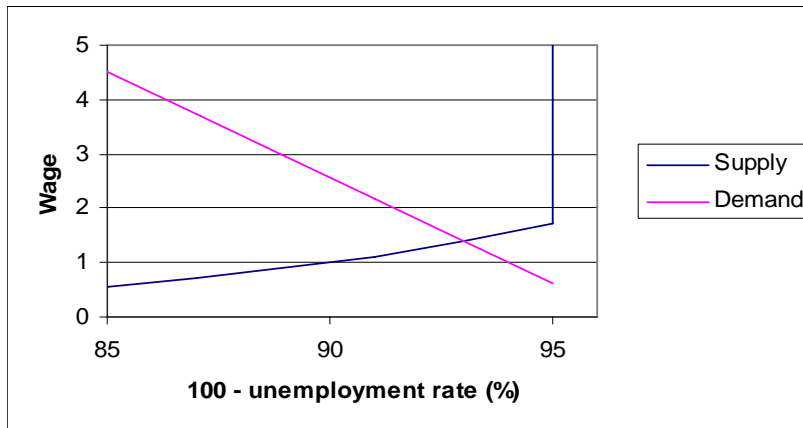
Steps in Simulation Analysis

☐ Run base (business-as-usual) scenario:
- Purpose: a plausible benchmark for comparisons
- GDP growth calibrated to trend from last 5-15 years;
- Balanced and sustainable evolution of macro aggregates (private and government consumption and investment; foreign and domestic debt stocks; tax revenues from different taxes; foreign grant aid …); many of these items may have unchanged GDP shares.

☐ Run alternative (counter-factual) scenarios. For example:
- Change one or more parameters (policy tools or parameters beyond government control, e.g. aid, world prices, productivity)
- Fix the evolution of a policy target (ex: a health MDG); flex a policy tool (ex: government health services).

☐ Analyze and validate:
- explain results for individual scenarios and across scenarios;
- validation is issue-specific
- if needed, adjust data, model, or simulation design.

3. Examples of Scenarios

☐ Questions commonly addressed by non-BASE scenarios: What happens if the government …

1. expands services sufficiently to reach the MDGs with additional financing provided by (a) foreign grants; (b) domestic taxes; (c) domestic borrowing?

2. contracts in one area (e.g. human development or other government) and expands in another (e.g. infrastructure) with unchanged aid and domestic policies?

3. in one or more areas, adjusts services to absorb changes in financing from a, b, or c (see 1)?

4. becomes more/less productive, adjusting one or more types of spending or financing in response?

4. Dominican Republic: A MAMS-Microsimulation Application

☐ Context: Input into the National Development Strategy of the DR.

☐ The MDG version of MAMS was applied to a 2007 DR database.

☐ MS used for poverty-inequality analysis.

MDG Key Indicators

	1990	2007	2015	
MDG 1: Poverty	28.6	37.7	14.3	% population
MDG 2: Net Primary School Completion	22	27	≈90?	% cohort
MDG 4: Under-five Mortality	58	35	19	Per 1000 births
MDG 5: Maternal Mortality	229	81	57	Per 100,000 live births
MDG 7a: Access to Safe Water	83	76	92	% population
MDG 7b: Access to Improved Sanitation	60	97	80	% population

Note: Nearest available year if data not available for 1990 or 2004.
Value for Poverty (MDG 1) based on year 1998.

Determinants of non-poverty MDGs: (1) Service delivery; (2) Per-capita household consumption; (3) Public Infrastructure; (4) Wage incentives; and (5) Other MDGs.

Simulations and Results

Simulations

- **BASE** - Baseline Scenario
- **TAX** - MDG scenario with domestic taxes closing the government budget
- **FB** - MDG scenario with foreign borrowing closing the government budget
- **TRDOFF** - Trade-off scenarios between HD and Infrastructure spending

Baseline assumptions

- Simulations run for 2007-2015.
- 5% GDP growth – close to trend 1970-2005
- Government consumption growth:
  - Overall growth near 4.2%
  - Primary education: growth sufficient to gradually raise services per student by 35% by 2015.

MDG scenario assumptions

- Simultaneous achievement of all model MDGs by 2015.
- MDGs targeted via endogenous variations in government demand (consumption) of relevant services.
- Alternative sources of financing of the required increase in government expenditure:
  - Domestic taxes
  - Foreign borrowing.
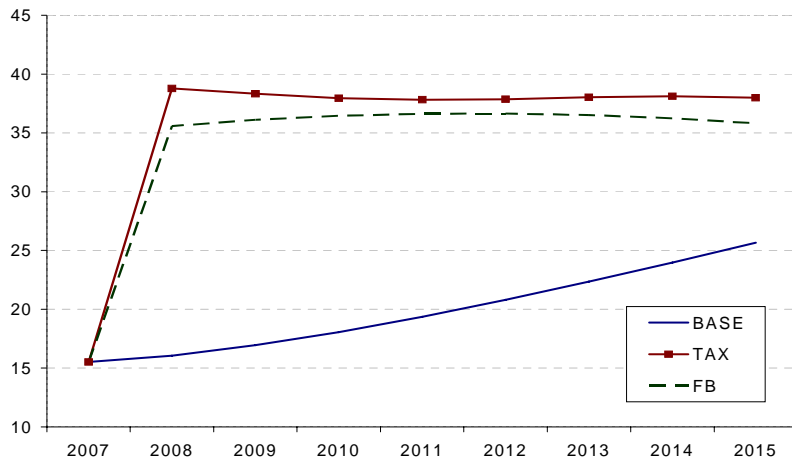
Table 1. Simulation Results

	2007	**BASE**	**TAX**	**FB**
	RD$ bn	*% annual growth 2007-2015*		
Consumption - prv	1,128.7	4.6	3.5	5.0
Consumption - gov	101.5	4.2	9.4	9.0
Investment - prv	195.2	4.7	3.5	5.0
Investment - gov	63.0	0.3	8.1	5.1
Exports	392.6	6.1	5.2	4.4
Imports	516.7	4.4	3.8	5.3
GDP at f.c.	1,235.1	5.0	4.7	5.1
Tot factor empl (index)		2.3	2.7	3.0
Real exch rate (index)		0.5	0.9	-0.4
	% GDP	*% GDP*		
Net indirect taxes	9.5	8.6	13.2	8.1
Foreign gov debt	13.0	13.6	14.1	81.5

MDG Results

□ Accelerated government consumption and investment growth.

□ Health most expensive for DR; grows steadily, becoming more expensive in second half.

□ Education requires a lot of up-front spending; need to reach 2008 target.

Government Expenditure on Primary Education (DR$ billion)
Baseline and MDG Simulations

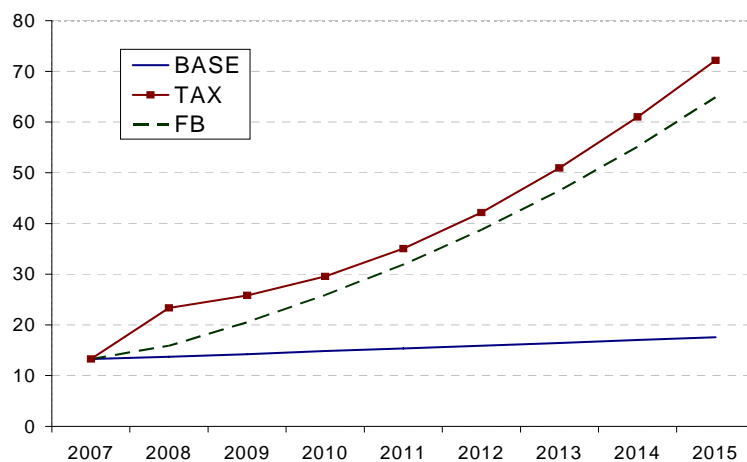# Government Expenditure on Health (DR$ billion)
Baseline and MDG Simulations

Table 2. Poverty and Inequality Results

			2015		
	Goal 2015	2007	BASE	TAX	FB
MDG 1: Poverty Rate	14.3	37.7	27.5	28.9	25.5
MDG 2: Primary School Completion Rate	100	27	52	92	92
MDG 4: Under-five Mortality Rate	19	35	25	19	19
MDG 5: Maternal Mortality Rate	57	81	67	57	57
MDG 7a: Access to Safe Water	92	76	82	92	92
MDG 7b: Access to Improved Sanitation	80	97	97	98	98
Gini		0.497	0.502	0.495	0.491

Trade-off scenario assumptions

- ☐ Exogenous variation of investment in government infrastructure capital.
- ☐ Endogenous adjustment in HD (health, education, water-sanitation) spending to respect fiscal space limits.
- ☐ Factors influencing the results:
  - Growth in HD services has a positive impact on HD MDGs.
  - Growth in infrastructure capital stocks raises TFP, GDP and private consumption and investment.
  - The marginal returns from infrastructure capital stocks are diminishing
  - Slower growth in more educated labor reduces GDP growth.

Figure 3. Poverty-HD Trade-off
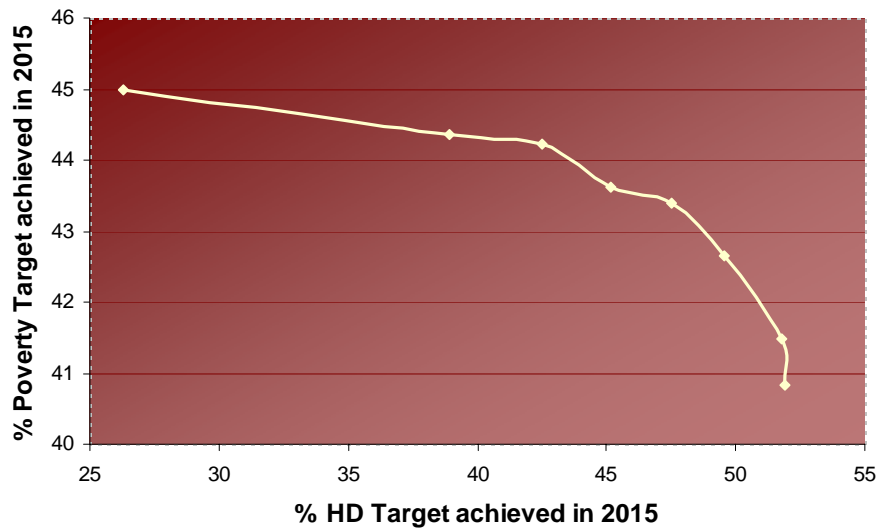
Results

- □ In spite of considerable progress across the board, the DR cannot achieve its MDGs under current policies and investment levels.
- □ Very difficult to achieve all MDGs, especially in health and education.
- □ DR government allocates relatively small share of GDP to social sectors as compared to other countries in LAC.
- □ Effect of large expansion in government services very much depends on the financing mechanism.

Results (cont.)

☐ If marginal financing needs met by foreign borrowing, then no trade-off between poverty reduction and growth promotion versus achievement of non-poverty MDGs.

☐ However, DR unlikely to further raise its foreign debt and debt-servicing burden.

☐ Rapid growth is crucial for achievement of the MDGs.

5. Policy insights from country studies

☐ Human development (HD) vs. infrastructure:

- Additional infrastructure spending has a more positive short-to medium-run growth impact while also having positive HD effects.

- Balanced scenarios (expanding both infrastructure and HD) are more attractive in terms of outcomes (extreme scenarios face diminishing marginal returns) and politics.

Insights (cont.)

- Income distribution:
  - A major short- to medium-run effect of scaled-up HD spending is higher wages of the more educated throughout the economy (also in the private sector), putting sectors that are intensive in educated labor at a cost disadvantage.
  - In the long run, this relative-wage switch may be reversed as scaled up education spending raises the supply of educated labor.

Insights (cont.)

- Domestic financing vs. foreign aid:
  - Reliance on domestic sources to finance additional spending involves difficult short- to medium-run trade-offs between the poverty MDG and other MDGs.
  - Reliance on aid for marginal financing makes trade-offs easier.

Insights (cont.)

- Foreign aid and Dutch disease (DD):
    - The strength of DD effects depends on the marginal import share of government spending.
    - DD effects are stronger for HD-focused scenarios in so far as additional spending is on non-tradables.
- Slower export growth and faster import growth (common effects of more aid) are "disease" symptoms if the aid makes a needed future export/import growth reversal more difficult.

Insights (cont.)

- Government efficiency:
    - Feasible reallocations over time from areas with small or no returns can lead to noticeable improvements in performance.
    - What is feasible is highly country-specific.

Insights (cont.)

□ Be cautious!

  ■ Issues are complex, model structure and parameter values are uncertain ➔ analysts should present the simulation results with humility, viewing them as aids to thinking that should be cross-checked against insights based on other methods and intuition.

6. Summary/Conclusions

□ MAMS: a tool for analyzing the impact of alternative scenarios on economic development, including monetary poverty and other MDGs.

□ DR simulation analysis illustrates the application of MAMS to the analysis of alternative MDG scenarios and trade-offs between HD and infrastructure spending.

Summary/Conclusions

- The Road Ahead:
  - better specifications of dynamic household behavior (savings/investment, demography, migration), markets (segmentation, space, transactions costs)
  - careful issue/country-specific applications of existing tools
  - development of versions that addresses environmental policy issues, permitting integrated analysis of MDGs and the environment.

Key References

- Bourguignon, Francois, Carolina Diaz-Bonilla, and Hans Lofgren. 2008. "Aid, service delivery and the Millennium Development Goals in an Economywide Framework," pp. 283-315 in François Bourguignon, Maurizio Bussolo, and Luiz A. Pereira da Silva, eds. <u>The Impact of Macroeconomic Policies on Poverty and Income Distribution: Macro-Micro Evaluation Techniques and Tools</u>. Washington, D.C.: World Bank. Also issued as World Bank Policy Research Working Paper 4683.
- For more, see: www.worldbank.org/mams

Appendix 1. Data

- Core needs are similar to other CGE models:
    - Social Accounting Matrix (SAM); stocks of factors, population, and debts (foreign and domestic); elasticities in trade, production, and consumption;
    - They depend on the (flexible) disaggregation of the model.
    - The SAM is used to define most of these parameters.

Data for MDG version

- Requirements specific to MDG version:
    - In SAM: government consumption and investment disaggregated by MDG-related functions; labor disaggregated by educational achievement;
    - Education parameters: stocks of students by educational cycle; student behavioral patterns (ex: rates of passing, repetition, dropout); population data with some disaggregation by age;
    - MDG data: indicators for base-year and 1990; elasticities; calibration scenario for achieving each MDG.

Data sources

- ☐ Database draws on a wide range of sources.
- ☐ Likely key sources:
  - Standard national data publications (national accounts, government budget, balance of payments)
  - World Development Indicators (WDI) (labor stocks; value-added in agr/ind/ser; population)
  - Public Expenditure Reviews and Country Economic Memoranda
  - Sectoral MDG studies (health, education, water-sanitation, public infrastructure)
  - Existing SAMs and input-output tables
  - Surveys (household, labor, DHS)

Appendix 2: MAMS vs. RMSM-X

Table. MAMS vs. RMSM-X

	MAMS	RMSM-X
Time frame	medium- to long-run	short- to medium-run
Accounting consistency	yes	yes
Economic behavior	more emphasized	less emphasized
Production function	labor, capital, land intermediates	capital
Monetary sector	no	yes
Disaggregation	more	less
Data requirements	more	less
Software	GAMS/Excel	Excel

Appendix 3. Poverty Analysis with MAMS

- Two basic approaches to poverty and inequality analysis using MAMS and other CGE models:
  - representative household (RH)
  - microsimulation (MS)
- Both generate standard poverty and inequality indicators.
- For details, see Appendices 4 and 5.

Appendix 4: Representative Household Approach to Poverty Analysis

- MAMS includes one or more RHs.
- Each RH is characterized by:
  - pattern of incomes (factors, transfers, interest)
  - pattern of outlays (taxes, saving, consumption, transfers)
  - behavioral assumptions (given by elasticities)
- Changes in RH receipts and outlays are generated as part of model simulations.

Representative Household Approach

- ☐ The basic assumption of the RH approach: the relative within-group income (or consumption) distribution for each RH does not change (under the scenarios that are analyzed);
- ☐ The more homogeneous the individual households of the RH (in terms of shares for different incomes and outlays), the more valid the assumption.
- ☐ The distribution for each RH may be given by a household survey (a set of per-capita income observations with weights; each observation is mapped to a RH) or by a functional form with empirical parameters (for example: log-normal).

Representative Household Approach

- ☐ Steps in the analysis:
1. MAMS provides changes in mean per-capita income for each RH (by scenario and year);
2. the survey observations (the distribution) for each RH are scaled on the basis of the changes under (1);
3. simulated poverty (and inequality) statistics are computed for each RH and aggregated to the nation.
- ☐ MAMS is programmed to generate standard poverty indicators and the Gini coefficient for a household survey (provided in Excel) or assuming a log-normal distribution for each RH.

Appendix 5: Microsimulation approach to poverty analysis

□ "... instead of aggregating observations within a household survey into a few household groups in conformity with the requirements of CGE-type models, our aim should be to work directly with all the individual observations of the survey. By doing so, we hope to achieve full consistency between macroeconomic reasoning and standard poverty evaluation." Bourguignon, 1999.

Microsimulation

□ The essence of MS: model the behavior of the individual agents that are included in a survey.

□ In order to extend the analysis beyond partial-equilibrium issues, such MS models may be linked to the standard CGE model.

□ Alternative approaches:
- integrated CGE-MS model (each survey observation is an RH) – is this an MS or RH approach?
- sequential (top-down) approach with CGE model feeding MS model with data (prices, wages, incomes).

Microsimulation

- Alternative top-down approaches: (i) Random selection procedure; (ii) Econometric
- Constraints imposed by data in household surveys.
- In the context of top-down MS analysis, one RH in the CGE model may be sufficient.
- Standard poverty and inequality measurement tools can be applied to the resulting simulated household survey.

Microsimulation module for DR application

- Poverty and inequality analysis based on 2007 DR National Labor Force Survey.
- Linking variables:
  - Unemployment rate
  - Sector of activity
  - Sector-specific remuneration
  - Overall remuneration
  - Skill composition of employed
  - Non-labor income
- Random selection procedure within a segmented labor-market structure.