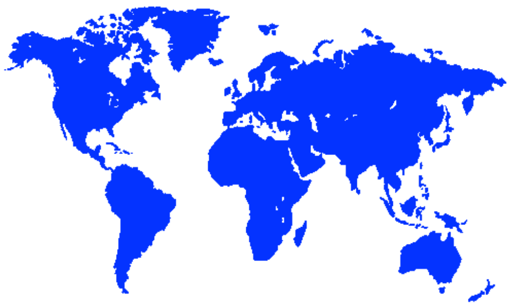

Analysis of Long-Term Global Social Change:

Using Universal Social Accounting Matrices (SAMs) in the International Futures (IFs) Modelling System

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Abstract

This paper describes work underway in creating and using an integrated model for the analysis of long-term, global social development and performance. The paper describes a specific effort within the larger modelling project, namely the creation and use of universal social accounting matrices (SAMs) for dynamic analysis of social performance in countries around the world.

The universal social accounting matrices (SAMs) have been developed within an existing integrated global model named International Futures (IFs) that contains: a cohort-component representation of demographic systems; a multi-sector, general equilibrium-seeking representation of economies; a module of formal education at primary, secondary, and tertiary levels; and other subsystems. The IFs system also facilitates the development and comparison of multiple scenarios for underlying variables and subsystems as disparate as the rate of change in systemic multifactor productivity, the evolution of the HIV/AIDS epidemic, and the attention that societies give to different levels of education.

The net for data sources and methods for generating the matrices and creating forecasts for a wide range of countries was cast wide, but a few sources were of particular importance. These include the Global Trade Analysis Project (GTAP), the World Bank (especially its World Development Indicators), and the Organization for Economic Cooperation and Development (OECD).

Specific issues that such a modelling system can help investigate include the unfolding pension crises of many developed countries and the effort to strengthen basic social safety nets or social protection systems throughout the developing world. The modelling system is also being structured so as to provide insights into changing income distributions within and across countries.

1. Introduction: Analysis Purposes

The broad purpose of the International Futures (IFs) modelling system is to serve as a thinking tool for the analysis of long-term country-specific, regional, and global futures across multiple, interacting issue areas. With respect to social development and performance, such futures can range from state failure, at one extreme, through rapid social development with stability and democratization, at the other extreme.[1]

More economically-developed countries have increasingly identified the funding of pension plans in the face of rapidly aging populations as a critical issue. For instance, the Center for Strategic and International Studies (CSIS) has issued a series of reports. England (2001) authored *The Fiscal Challenge of an Aging Industrial World* and followed (2002) with *Global Aging and Financial Markets: Hard Landings Ahead?* CSIS also sponsored a report by Hewitt (2002) called *Meeting the Challenge of Global Aging: A Report to World Leaders from the CSIS Commission on Global Aging*. Ryutaro Hashimoto, Walter Mondale, and Karl Otto Pöhl chaired that 85-member commission.[2]

Two issues of interest to us here tend to dominate the discussion of possible pension crises: the immediate fiscal problems for states that have pay-as-you-go pension plans and aging populations; and the larger macro-economic implications of changing ratios between those of employment age and the larger population.

Less economically-developed countries face, of course, even more immediate and pressing problems. The Millennium Summit's Development Goals (declared in September, 2000) are only a recent set within a long series of efforts to state objectives

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[1] The developments to International Futures that have made possible the model development and analysis described here have been funded in substantial part by the TERRA project of the European Commission and by the Strategic Assessments Group of the U.S. Central Intelligence Agency. They have been increasingly motivated also by the Frederick S. Pardee Center for Longer Range Global Policy and the Future Human Condition. In addition, the European Union Center at the University of Michigan has provided important support for enhancing the user interface and ease of use of the IFs system. None of these institutions bears any responsibility for the analysis presented here, but their support has been greatly appreciated. Thanks also to the National Science Foundation, the Cleveland Foundation, the Exxon Education Foundation, the Kettering Family Foundation, the Pacific Cultural Foundation, the United States Institute of Peace, and General Motors for funding that contributed to earlier generations. Also of great importance, IFs owes much to the large number of students, instructors, and analysts who have used the system over many years and provided much appreciated advice for enhancement (some are identified in the Help system). The project also owes great appreciation to Anwar Hossain, Mohammod Irfan, and José Solórzano for data, modelling, and programming support of the most recent model generation, and to earlier student participants (again see the Help system).

[2] Many others have weighed in concerning the growing challenge of pension funding. The World Bank (1994) provided an early and still seminal analysis. See Orszag and Stiglitz (1999) for an updated and extended analysis. The OECD has weighed in with studies such as its *Ageing in OECD Countries: A Critical Policy Challenge* (1996) The Population Reference Bureau published an issue of its Reports on America called *Government Spending in an Older America* (Lee and Haaga 2002). The Council of Ministers of the European Union met in Barcelona in early 2002 and the issue was high on its agenda.

for addressing poverty in LDCs.[3] The summit's summary statement is, nonetheless, very important: "We will spare no effort to free our fellow men, women, and children from the abject and dehumanizing conditions of extreme poverty to which more than a billion of them are currently subjected."

Although very large numbers of intergovernmental and nongovernmental organizations have been involved and continue to be active in achieving summit goals such as eradicating extreme poverty, the World Bank has taken an important role through its research and field programs, such as those aimed at implementing "poverty reduction strategies" and creating "social protection" (World Bank 2000; Holzmann and Jørgensen 2000). One of the desired elements of social protection has long been the extension of social safety nets, focusing sometimes on assuring basic levels of income for all and sometimes on specific targets such as food for children, support for the unemployed, or adequate pensions for the retired. The IMF also well recognizes the need for such safety nets, especially in light of the highly-criticized negative side effects of globalization.[4]

Perhaps the key difference between traditional emphases on safety nets and emerging approaches to social risk management is the recognition that temporary, palliative assistance to those in greatest need (safety nets alone) is best addressed as part of the larger problem of meeting needs in the context of broader economic and social development (not least of which is the creation of strong educational systems). The central issue of interest to us here therefore tends to be the creation of what might be called a "sustainable safety net," namely the ongoing and increasing generation/provision of basic levels of income and social support in a growing economy and a developing socio-political system.

2. General Characteristics of the Approach

Analysis of long-term social change, including addressing of problems such as those identified above, requires tools that have empirical foundation, analytic strength and very considerable breadth. Much can be learned from simple extrapolative techniques (often used in looking at pension issues) or from relatively narrowly-focused models (much development study benefits from them). Particularly as the geographic scope and the temporal range of interest expand, however, the potential contribution of larger scale, integrated and dynamic models becomes greater.

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[3] The United Nations Development Program's 2002 report has a good statement of the Millennium Goals at http://www.undp.org/hdr2002/. See www.develeopmentgoals.org for a very useful statement by the World Bank.

[4] The December 16, 2002, issue of the IMF Survey (see www.imf.org/imfsurvey) reported on a conference on social safety needs sponsored by the International Labor Organization, the Carnegie Endowment for International Peace, and the Brookings Institution.

2.1 Static and Dynamic Foundations

More specifically, analysis of the issues identified above can benefit from an approach with two foundational elements: one essentially static and the other highly dynamic.[5] The first element is a snapshot at a point in time of the interactions of the economy and the broader society, ideally with some significant level of disaggregation. We want, for instance, to understand the production and consumption patterns of a society, the income distribution within it, and the role that governments take in transferring resources among households and firms over time. We want to see the relationship between such elements within and between societies.

Social Accounting Matrices (SAMs) provide such a snapshot. A SAM integrates a multi-sector input-output representation of an economy with the broader system of national accounts, also critically representing flows of funds among societal agents/institutions and the balance of payments with the outside world. Richard Stone is the acknowledged father of social accounting matrices, which emerged from his participation in setting up the first systems of national accounts.[6] It is fitting that the 1993 revision of the System of National Accounts by the United Nations has begun explicitly to move the SNA into the world of SAMs. Many others have pushed the concepts and use of SAMs forward, including Pyatt (Pyatt and Round 1985) and Thorbecke (2001). So, too, have many who have extended the use of SAMs into new frontiers. One such frontier is the additional representation of environmental inputs and outputs and the creation of what are coming to be known as Social and Environmental Accounting Matrices (SEAMs). See Pan (2000). Another very productive extension is into the connection between SAMs and technological choice of a society (see Khan 1998; Duchin 1999).[7]

It is probably safe to forecast that some version of social accounting matrices will ultimately become the standard snapshot of socio-economic systems. At this point, however, SAMs have become numerous, but remain generally country-specific and are something of an art to construct. Large numbers are available through the enterprise of organizations such as the International Food Policy Research Institute, using the GAMS software (Robinson and El-Said 2000).

The second foundational element for analytic study of social change is a dynamic model into which to put a representation like that of a SAM. Again Stone was a pioneer,

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[5] Pentti Malaska of the Finland Futures Research Centre (FFRC) and the TERRA project has elaborated a perspective on modelling and documentation of models that involves synchronic and diachronic elements. His perspective has helped inform the discussion here.

[6] Pesaran and Harcourt (1999) provide a wonderful description of the emergence of his tremendous body of scholarship; it is hardly surprising that authors who provide a single citation for the foundations of social accounting matrices seldom agree on the appropriate work. Nonetheless, one especially good presentation by Stone was in his Nobel Memorial Lecture (Stone 1986).

[7] Faye Duchin, who worked with Wassily Leontief on the UN World Model in the 1970s, has been an active proponent of SAM-based analysis. She was instrumental as an early reviewer in the TERRA project in the decision to develop a SAM structure within IFs.

leading the Cambridge Growth Project with Alan Brown. That project placed SAMs into a broader modelling framework so that the effects of changes in assumptions and coefficients could be analyzed, the predecessor to the development and use of computable general equilibrium (CGE) models by the World Bank and others. Some of the Stone work continues still with the evolution of the Cambridge Growth Model of the British economy (Barker and Peterson, 1987). Kehoe (1996) reviews the emergence of applied general equilibrium (GE) models and their transformation from tools used to solve for equilibrium under changing assumptions at a single point in time to tools used for more dynamic analysis of societies.

The approach described here is both within these developing traditions and an extension of them on three fronts. The first extension is in universality of the SAM representation. As noted, most SAMS are for a single country or a small number of countries or regions within them (see Bussolo, Chemingui, and O'Connor 2002 for a multi-regional Indian SAM within a CGE). The project here has created a procedure for constructing relatively highly aggregated SAMs from available data for 164 different countries, relying upon estimated relationships to fill sometimes extensive holes in the available data. Each SAM has an identical structure and they can therefore be easily compared or even aggregated (for regions of the world).

The second (now emerging) extension is the connecting of the universal set of SAMs through representation of the global financial system, both stocks and flows. The specification under construction includes foreign direct investment, private debt, IMF credits and World Bank loans, government external debt, and reserve holdings. The flows calculated for the country-specific SAMs will provide the dynamics for changing asset and liability values. The stocks of assets and liabilities will in turn help drive the behaviour of agent classes in shaping the flow matrix.

The third extension is temporal. The SAM structure described here has been embedded within a long-term global model called International Futures (IFs). The economic module of IFs has many of the characteristics of a typical CGE, but IFs also includes a number of other submodels relevant to the creation of longer-term forecasts, including a cohort-component based demographic model . Efforts have been made to provide a dynamic base for demographic and economic drivers of the IFs model such that forecasts can be made well into the 21st century. It is important to quickly emphasize that such forecasts are not predictions. Instead they are scenarios to be used for thinking about possible alternative longer-term futures.

2.2 The IFs Modelling Platform

International Futures (IFs) has been evolving for more than 20 years in support of investigation into global demographic, economic, social, and environmental transitions. Integrated modelling offers a number of advantages that supplement individual issue analyses:

1. The ability to compare the impact that alternative policy levers produce relative to a range of goals within a consistent framework. No modelling system will ever provide a comprehensive representation of all complex underlying systems, but over time such a system can evolve so as to capture what analysts identify as the dominant relationships and the dominant dynamics within them.

2. The potential to explore secondary and tertiary impacts of policy interventions or of attaining policy targets. For instance, we know that rebound effects are persistent in many systems that have a general equilibrating character; without the representation of such equilibration, such rebound effects are difficult, if not impossible, to analyze.

3. The option of exploring interaction effects among the policy interventions themselves. Ideally we want to consider interventions individually, in order to isolate the leverage they provide us, but also to investigate them in combinations that might, on one hand, represent politically feasible policy packages or, on the other hand, maximize our ability to reach goals.

Full documentation of the International Futures (IFs) modelling system, albeit somewhat behind recent model developments, exists in the on-line help system of the system itself. The system is now in its fourth generation. For introduction to the character and use of the third generation see Hughes (1999). The IFs system has evolved rapidly in the last three years. Here we provide only very basic summary information on the structure of the system and on its capabilities for support of scenario analysis, before turning to the primary purpose of this paper, namely the new SAM structures and the analysis that can be based on them.

International Futures is a global modelling system. The extensive data base underlying it includes data for 164 countries over as much of the period since 1960 as possible. The modelling system has a "pre-processor" that cleans and reconciles data from a variety of sources and across a variety of units, then aggregates it into initial conditions and parameters for whatever geographic representation of the world the user desires. The model itself is a recursive system that can run without intervention from its initial year (currently 2000); the model interface facilitates interventions flexibly, however, across time, issue, and geography.

2.3 Modules in International Futures

Figure 2.1 shows the major conceptual blocks of the International Futures system. The elements of the technology block are, in fact, scattered throughout the model.

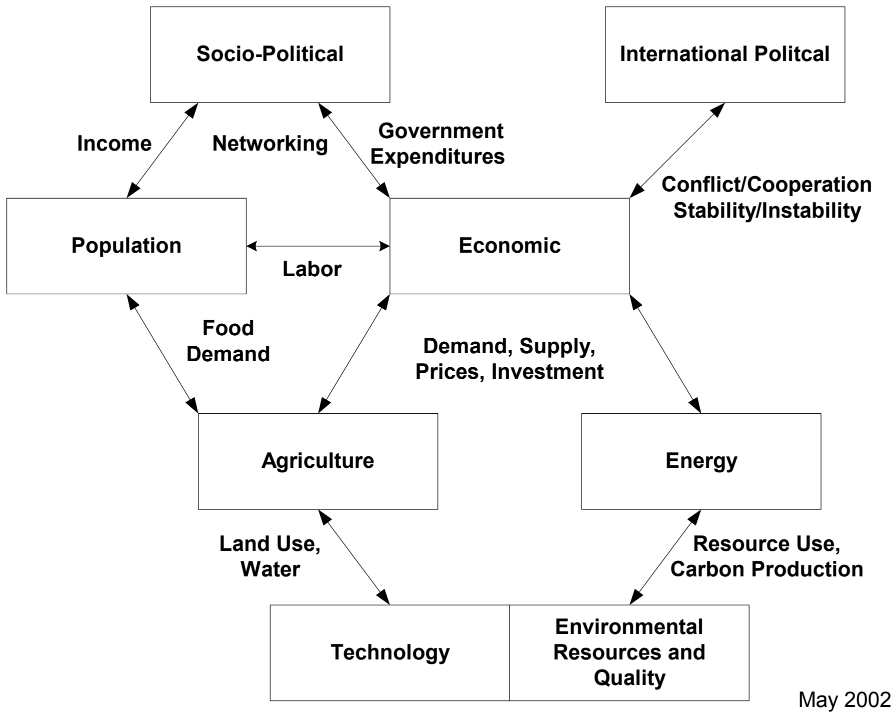


Figure 2.1 An Overview of International Futures (IFs) for TERRA

The population module:

- represents 22 age-sex cohorts to age 100+
- calculates change in cohort-specific fertility and mortality rates in response to income, income distribution, and analysis multipliers
- computes average life expectancy at birth, literacy rate, and overall measures of human development (HDI) and physical quality of life
- represents migration and HIV/AIDS
- includes a newly developing submodel of formal education across primary, secondary, and tertiary levels

The economic module:

- represents the economy in six sectors: agriculture, materials, energy, industry, services, and ICT (other sectors could be configured, using raw data from the GTAP project)
- computes and uses input-output matrices that change dynamically with development level
- is a general equilibrium-seeking model that does not assume exact equilibrium will exist in any given year; rather it uses inventories as buffer stocks and to provide price signals so that the model chases equilibrium over time
- contains a Cobb-Douglas production function that (following insights of Solow and Romer) endogenously represents contributions to growth in multifactor productivity from R&D, education, worker health, economic policies (“freedom”), and energy prices (the “quality” of capital)

- uses a Linear Expenditure System to represent changing consumption patterns
- utilizes a "pooled" rather than the bilateral trade approach for international trade
- has been imbedded in a social accounting matrix (SAM) envelope that ties economic production and consumption to intra-actor financial flows

The agricultural module:

- represents production, consumption and trade of crops and meat; it also carries ocean fish catch and aquaculture in less detail
- maintains land use in crop, grazing, forest, urban, and "other" categories
- represents demand for food, for livestock feed, and for industrial use of agricultural products
- is a partial equilibrium model in which food stocks buffer imbalances between production and consumption and determine price changes
- overrides the agricultural sector in the economic module unless the user chooses otherwise

The energy module:

- portrays production of six energy types: oil, gas, coal, nuclear, hydroelectric, and other renewable
- represents consumption and trade of energy in the aggregate
- represents known reserves and ultimate resources of the fossil fuels
- portrays changing capital costs of each energy type with technological change as well as with draw-downs of resources
- is a partial equilibrium model in which energy stocks buffer imbalances between production and consumption and determine price changes
- overrides the energy sector in the economic module unless the user chooses otherwise

The socio-political sub-module:

- represents fiscal policy through taxing and spending decisions
- shows six categories of government spending: military, health, education, R&D, foreign aid, and a residual category
- represents changes in social conditions of individuals (like fertility rates or literacy levels), attitudes of individuals (such as the level of materialism/postmaterialism of a society from the World Value Survey), and the social organization of people (such as the status of women)
- represents the evolution of democracy
- represents the prospects for state instability or failure

The international political sub-module:

- traces changes in power balances across states and regions
- allows exploration of changes in the level of interstate threat
- represents possible action-reaction processes and arms races with associated potential for conflict among countries

The environmental module:

- allows tracking of remaining resources of fossil fuels, of the area of forested land, of water usage, and of atmospheric carbon dioxide emissions
- provides a display interface for the user that builds upon the Advanced Sustainability Analysis system of the Finland Futures Research Centre (FFRC), Kaivo-oja, Luukhanen, and Malaska (2002)..

The distributed technology module:

- is scattered throughout the overall model
- allows changes in assumptions about rates of technological advance in agriculture, energy, and the broader economy
- explicitly represents the extent of electronic networking of individuals in societies
- is tied to the governmental spending model with respect to R&D spending

2.4 The Presentation to Follow

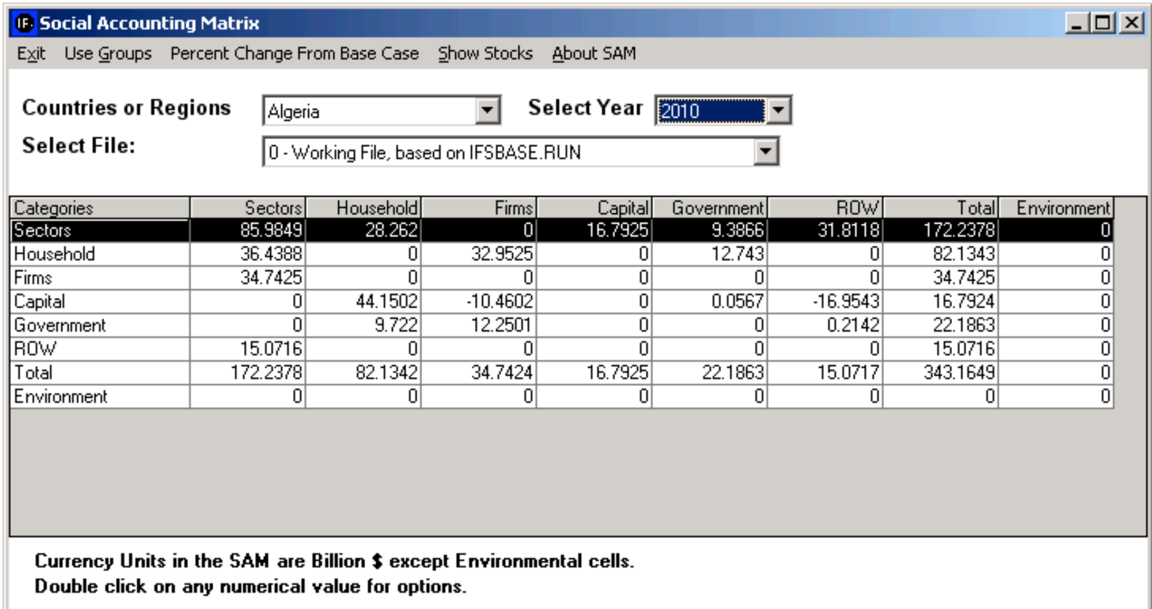
The next chapter of this report outlines in brief the basic elements of the SAM in this project and the way in which the SAM is integrated into the International Futures system, focusing on how it looks to the user of the system. Chapter 4 will then detail the construction and character of the system, beginning with the input-output matrices and continuing across social actors/institutions. Then Chapter 5 will turn to the actual use of the system for the study of long-term social change.

3. An Overview of the Universal SAM

For details on the system, readers can turn to the next chapter of the full report (this paper cannot provide that level of detail; the full paper, a living/working document, is available upon request). This chapter gives a birds-eye view of the SAM structure within the IFs model, hopefully facilitating a more detailed look.

3.1 Elements and Structure

International Futures (IFs) has a menu-driven interface to facilitate investigation of the model's base case, creation of alternative scenarios, and exploration of an extensive data base via longitudinal and cross-sectional analysis. Figure 3.1 shows one of the specialized displays that the interface can generate from the base case or other scenario runs of the model, namely a basic social accounting matrix, this particular one being from the base case for Algeria in the year 2010. The matrix in that figure is in a standard, but rolled-up form, not showing any detail for individual economic sectors or household types. As the options on the screen suggest, it is possible to move quite easily across years, to change the country or region selected, to aggregate the matrix for a grouping of countries (such as the European Union), or to compute the percentage change between the matrix for a new scenario and that of the base case.



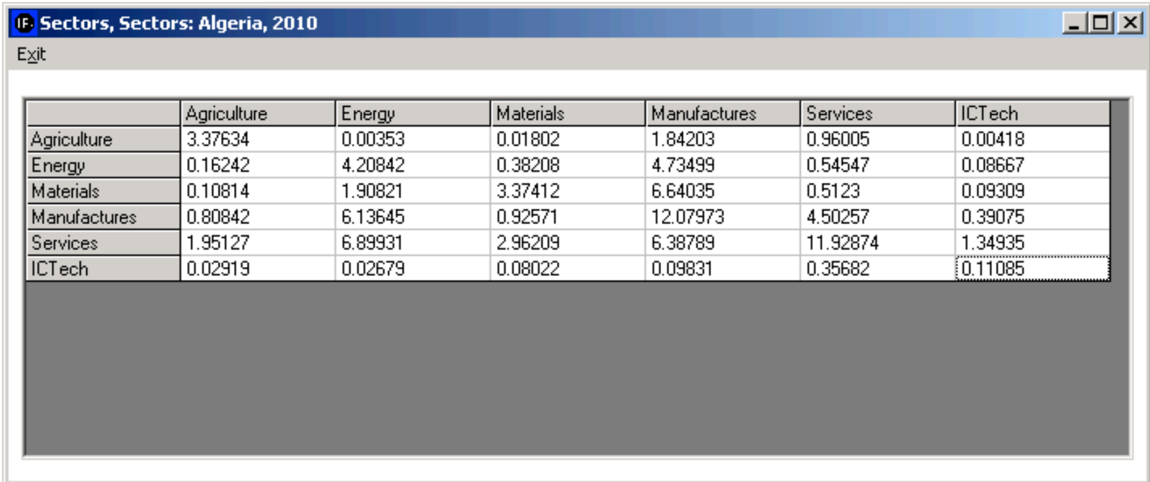
Categories	Sectors	Household	Firms	Capital	Government	ROW	Total	Environment
Sectors	85.9849	28.262	0	16.7925	9.3866	31.8118	172.2378	0
Household	36.4388	0	32.9525	0	12.743	0	82.1343	0
Firms	34.7425	0	0	0	0	0	34.7425	0
Capital	0	44.1502	-10.4602	0	0.0567	-16.9543	16.7924	0
Government	0	9.722	12.2501	0	0	0.2142	22.1863	0
ROW	15.0716	0	0	0	0	0	15.0716	0
Total	172.2378	82.1342	34.7424	16.7925	22.1863	15.0717	343.1649	0
Environment	0	0	0	0	0	0	0	0

Figure 3.1. Rolled-Up Social Accounting Matrix (SAM) from IFs

The convention for social accounting matrices is that each cell shows the flow from a column to a row. Thus we can see that governments are expected to provide households transfer payments of $12.7 billion dollars while households provide government with $9.7 billion in various forms of taxes or other payments.

It is also conventional to place an intersectoral flow matrix across some representation of economic sectors in the upper left-hand cell, and then to wrap flows between those economic sectors and several different classes of social agents or institutions in the top rows and left-most columns. The most common of these classes of agents or institutions are households, firms/businesses, and government. In addition we often see a representation of a capital account and of interactions with the rest of the world (ROW). The remaining cells of the matrix represent inter-agent flows. In each case, the column and row totals should be the same for any category. The matrix above has added environmental rows and columns that will be developed over time as a SEAM is elaborated from the SAM, but those cells now contain only zeros. The values in those cells will, however, differ from other cells in that all other cells are monetary values and the environmental cells will represent physical units (such as thousand cubic meters of water input or tons of carbon output).

In the IFs system, clicking on any non-zero cell elicits a pop-up box (not shown above) with two options. The first is to expand the cell, if there is more detail available. For instance, clicking on the Sector by Sector column and selecting the expand option brings up the table in Figure 3.2. The IFs economic model in its current configuration (more on this in Chapter 4) represents 6 economic sectors, five fairly standard ones and a sixth (information/communications technology) that was created for analysis within the TERRA project sponsored by the European Commission. Again, we can see flows from any column sector to any row sector, such as a $4.7 billion flow from manufactures to energy for inputs from the energy sector.



	Agriculture	Energy	Materials	Manufactures	Services	ICTech
Agriculture	3.37634	0.00353	0.01802	1.84203	0.96005	0.00418
Energy	0.16242	4.20842	0.38208	4.73499	0.54547	0.08667
Materials	0.10814	1.90821	3.37412	6.64035	0.5123	0.09309
Manufactures	0.80842	6.13645	0.92571	12.07973	4.50257	0.39075
Services	1.95127	6.89931	2.96209	6.38789	11.92874	1.34935
ICTech	0.02919	0.02679	0.08022	0.09831	0.35682	0.11085

Figure 3.2. Intersectoral Flow Elaboration.

The other option IFs provides in a clicked cell is detail over time. Thus clicking on the firm column and government row (firm to government flows) and selecting that second option generates the table in Figure 3.3 (for whatever horizon the user has previously designated, potentially out to 2100). The elaborated entries in Figure 3.3 are general corporate taxes paid from firms to government, firm contributions to social security/pension schemes managed by the government, and indirect tax payments.

Sectors, Capital

	FIRMTAX[0]	FIRMGOVSS[0]	INDIRECTTAX[
	Algeria	Algeria	Algeria
Year	Billion $	Billion $	Billion $
2000	.609	.231	4.909
2001	.617	.234	4.969
2002	.707	.268	5.697
2003	.778	.295	6.265
2004	.899	.341	7.245
2005	1.005	.381	8.094
2006	1.066	.404	8.59
2007	1.16	.439	9.346
2008	1.208	.458	9.737
2009	1.244	.471	10.02
2010	1.298	.492	10.46
2011	1.282	.486	10.33
2012	1.363	.516	10.98
2013	1.356	.514	10.92
2014	1.449	.549	11.67
2015	1.463	.554	11.79
2016	1.581	.599	12.74
2017	1.604	.608	12.93
2018	1.732	.656	13.95
2019	1.843	.698	14.85
2020	1.878	.712	15.13
2021	2.028	.768	16.34
2022	2.091	.792	16.85
2023	2.174	.824	17.52

Figure 3.3 Elaboration of Firm to Government Flows.

Algeria is one of the worst possible countries that could be selected for display of data from the modelling system, because so few data are available in the sources that IFs draws upon. Chapter 4 discusses those data and the procedures used to generate base year (2000) and forecasted SAMs when data are scarce or poor.

3.2 Integration Within International Futures

Before turning to a description of the procedures underlying generation of the SAMs, it is useful to re-iterate that the SAMs are fully tied to the broader dynamics of the demographic, economic, and other sub-models of the IFs system. Figure 3.4 (generated using the more general display capability of IFs) shows a forecast for five of the many variables that are calculated in a run of the model. Population and population between the ages of 15 and 65 (the primary working years) come, of course, from the cohort-component demographic model. GDP comes from the economic model, as integrated with the SAM. In fact, the calculation of GDP is as the sum of the value added in each economic sector.

	POP[0]	POP15TO65[0]	GDP[0]	MFPRATET[0]	HDI[0]
	Algeria	Algeria	Algeria	Algeria	Algeria
Year	Mil People	Mil People	Billion $	Annl Rate	Index
2000	30.40	18.12	48.82	-.014	.699
2001	30.97	18.62	49.41	-.009	.698
2002	31.55	19.13	51.38	-.008	.70
2003	32.14	19.64	51.87	-.007	.698
2004	32.73	20.14	54.23	-.006	.701
2005	33.33	20.65	57.15	-.006	.706
2006	33.93	21.17	58.67	-.002	.707
2007	34.53	21.69	61.71	-.004	.711
2008	35.13	22.22	64.59	-.001	.716
2009	35.74	22.75	67.23	.001	.72
2010	36.34	23.29	71.18	.002	.726
2011	36.93	23.82	72.43	.005	.727
2012	37.52	24.35	76.65	.004	.733
2013	38.11	24.89	78.20	.009	.735
2014	38.70	25.42	82.60	.007	.741
2015	39.27	25.96	84.44	.011	.743
2016	39.84	26.38	89.35	.01	.749
2017	40.41	26.81	91.03	.013	.75
2018	40.97	27.23	95.28	.011	.755
2019	41.52	27.65	100.6	.015	.762
2020	42.05	28.06	102.1	.015	.763
2021	42.59	28.48	106.4	.013	.767
2022	43.11	28.90	108.7	.016	.769
2023	43.62	29.31	110.4	.013	.769
2024	44.12	29.70	112.6	.013	.77
2025	44.61	30.09	114.3	.015	.771

Figure 3.4. Variables Forecast by the Larger IFs System.

The value of GDP is not, however, determined by the SAM, which is simply an accounting of the flows indicated. Instead, the model uses a Cobb-Douglas style production function that determines value added in each economic sector. As indicated above, following the insight of Solow and heeding the advice of Romer, there is a relatively elaborate endogenization of multifactor productivity (MFP) in that model equation. The fourth column shows a calculation of the aggregate growth in MFP in the base case (with Algeria represented in the base case as moving from poor rates in recent years to rates more in line with its potential as a developing country; such rates could easily be changed for a different scenario).

Finally, the last column in Figure 3.5 shows a forecast for the United Nations Development Program's Human Development Index (HDI), which aggregates three sub-indices representing life expectancy, GDP, and educational expenditures/attainment. The first two inputs clearly are derived from the demographic and economic submodels of IFs, respectively. The third comes from a separate educational submodel that is linked to both demographic and economic representations.

4. Details of Development and Structure

This chapter provides information on the generation of initial or base year SAMs, as well as information on dynamics that generate SAMs in forecasts. In the full report (available upon request) this chapter is quite extensive. In this paper it is only possible to sketch the contents.

First, the chapter explains how the IO matrices of the Global Trade Analysis Project, Version 5, were used to created nine generic IO matrices representing different levels of GDP per capita. Those generic matrices where used for filling holes in the GTAP data set in order to initialize IFs for all countries in the world. In addition, they are used in the model itself in order to change matrices representing each country over time.

The chapter also explains how GTAP data on return to factors of production, land, unskilled labor, skilled labor, and capital, were used in defining the value added blocks of the SAM. Again, generic patterns related to GDP per capita were used to fill holes and to provide a basis for dynamically representing changes in those shares as countries develop.

Second, the chapter outlines the data used to flesh out the rest of the SAM matrix and the procedures used to reconcile inconsistencies and fill holes. Those steps involve use of a data pre-processor in the IFs system.

Third, the chapter explains the use of savings as a dynamic element across time. Government savings and external debt are stock terms that serve as touchstones for equilibrating mechanisms in the dynamics of the model. The modelling system also allows user flexible intervention, including specifications of changes in inter-agent flow patterns.

Fourth, the chapter provides information on the dynamic calculations of the SAM over time, focusing on the inter-agent transfers. The dynamics of the underlying goods and service markets are elaborated in the Help system of the model itself, as will be the equations of the SAM with further development of it.

5. Analysis

The purpose of this chapter is to introduce ongoing analysis using the combination of full demographic model, extensive economic model, and SAM representation of IFs. This chapter focuses first on issues around aging and pension plan funding in richer countries and second on broader issues of social safety nets and social protection in the developing world.

Before turning to analysis it is important to explain that SAMs are critical to the investigation here, but that it not always necessary or even particularly useful to look at the SAM itself in the analysis. Static or short-term analyses using SAMs often compare one SAM with another after intervention. Here our focus is multiple-issue, long-term, and geographically-wide. The critical importance of the SAM in such analysis is that it serves as an accounting structure, enforcing financial balances on and across agent classes. That is not to say that government expenditures will always equal revenues; in fact, they seldom will. But the SAM structure and the model around it computes imbalances and, over time, cumulative imbalances have consequences in terms of assets, liabilities, and future behaviour. That is, of course, true for households and firms as well as governments, and for countries with respect to external balances.

Thus with a SAM in place, increased government spending on pensions have consequences with respect to other spending and the need for revenue. Similarly, increased household income for unskilled households has implications for consumption and savings and those implications will flow across the system to firms and the government.

The analysis here will pose and address two simple questions as a way of demonstrating the capabilities of the system. Specifically, the following two sections briefly examine issues of aging populations and pension funding in Europe and enhancing human development in Sub-Saharan Africa. Again, the larger working document from which this paper is derived has more extended analysis.

5.1 Aging Population and Pensions in the European Union

Nearly every analyst agrees that one of the key questions facing Europe (with many other regions of the world not far behind) is how great a burden an aging population will be with respect to fiscal balances, growth, and even socio-political stability. Figure 5.1 provides some clear context for the question by looking at Italy, a country that illustrates the potential problem even better than do other European countries. Note the relative growth in the population above 65 compared to that below 15.

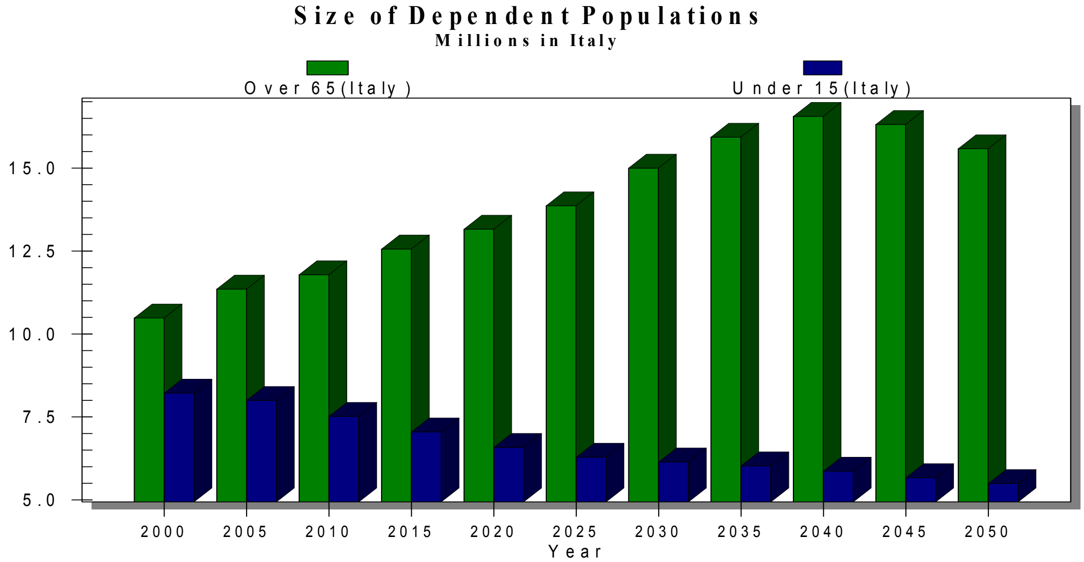


Figure 5.1 Size of Italian Dependent Populations: Over 65 and Under 15

One of the great unknowns concerning European demographic futures, and all that those futures will help shape, is the future of fertility rates. For the European Union, the Total Fertility Rate (TFR) is now just about 1.5 children per woman throughout her child-bearing years, well below the replacement rate of about 2.1.

The Base Case of IFs makes the assumption that fertility rates will actually climb somewhat over time, to above 1.7 by mid century and then to 1.9. This analysis contrasts the implications of that base case with two other scenarios. The Low Fertility case assumes that TFR stays at about 1.5. The High Fertility case raises it to 2.0 by 2050 and then to 2.5 in the longer term.

Figure 5.2 shows the dramatic differences these scenarios make for the number of people in the European Union (continuing to define the EU in terms of the current 15 members), especially in the longer term. The assumptions reshape European demography, beginning, of course, with those under 15.

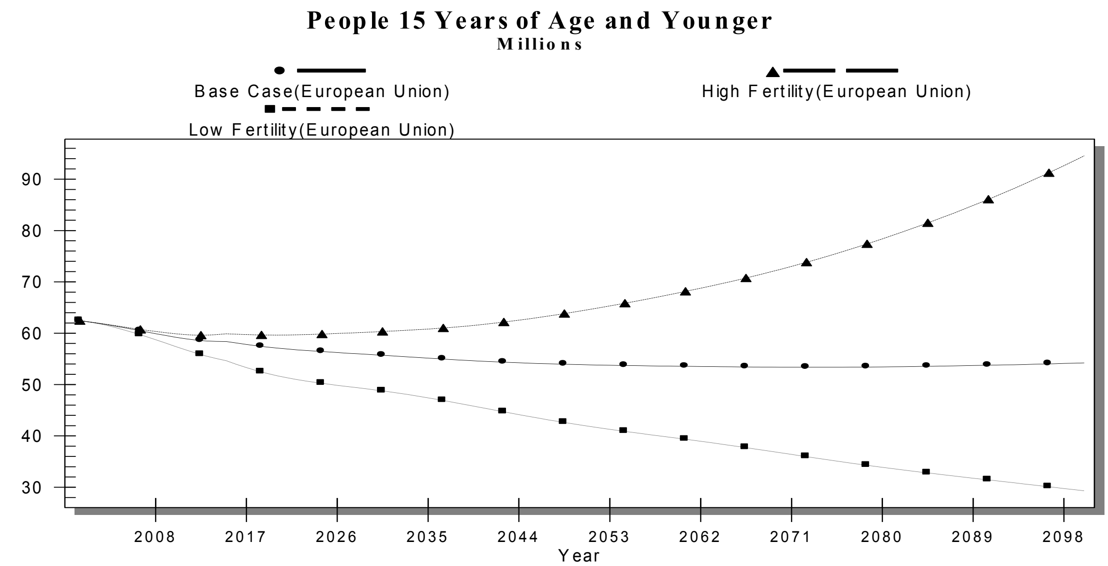


Figure 5.2 The Size of the Young Population in Three Scenarios

Intuitively, we might expect the differences in ability to care for the aged to vary quite directly with such demographic reshaping. Figure 5.3 shows that to be the case, but with considerable time delay. That figure shows for each scenario the government spending on pensions per citizen 65 years of age or old, divided by the per capita GDP of Europe. Note that over the longer term, that ratio deteriorates even in the base case, but especially in the low fertility scenario. For roughly the first 35 years, however, it does not change dramatically, either in absolute terms or across scenarios. The reasons are obvious upon reflection. First, the demographic structure changes relatively slowly, maintaining a relatively fixed ratio between pensioners and workers for about two decades. A second factor is that there is a "demographic dividend" for societies and governments in the short and mid-run in the low fertility scenario. Lower expenditures on the young can initially help offset the costs of a proportionately older population. (Not shown in these figures is the increasing burden of pensions on government across all scenarios.)

Figure 5.3 The Economic Well-Being of Pensioners in Three Scenarios

Obviously, this analysis could go much further in many directions. First, the focus here has been on government-provided pensions. How much difference does it make when schemes are private? Second, would pensioners (with large numbers and active political lives) accept such a deterioration? If not, what would their insistence on maintaining living conditions do to government fiscal balances and to the broader economy? These are the kinds of questions that SAMs, in combination with full population and goods/service economy submodels, can help answer and that this project will investigate over time.

5.2 Enhancing Human Development in Sub-Saharan Africa

Sub-Saharan Africa is widely recognized to be the most difficult global region with respect to development prospects. Many analysts despair at the prospects. Yet the Millennium Development Goals, as reformulated after Doha and Johannesburg meetings, set clear targets for the reduction of poverty, access to education, gender equity, and much more, even in Sub-Saharan Africa.

Let us again present three scenarios, directed by those goals. The first is the Base Case. The second scenario, called Self-Help, significantly increases spending from domestic sources by the Sub-Saharan countries on social programs aimed at providing a safety net for the poor: pension plans and broader social expenditures. The third scenario, Global Partnership, combines such increased spending with a partnership between rich and poor countries. Specifically, it increases foreign aid expenditures as a percent of GDP in OECD countries from about 0.24% to 0.74% over a period of 10 years (comparable to the target of the global partnership proposed in the Millennium Goals).

Figure 5.4 shows the government transfers per capita in Sub-Saharan Africa in the three scenarios (in thousand dollars). One of the most striking aspects of the figure is the very low level of transfers at the beginning of the analysis period, only about $50 per capita. That indicates both the depth of the problem and the potential for progress. The Self-Help scenario does increase those expenditures, but not dramatically. The resources are simply not there. The Global Partnership scenario is able to double the spending relative to the Base Case. Although a sceptical eye would question how much money from Global Partnership might actually reach poorer households, this scenario assumes away a possible increase in kleptocracy.

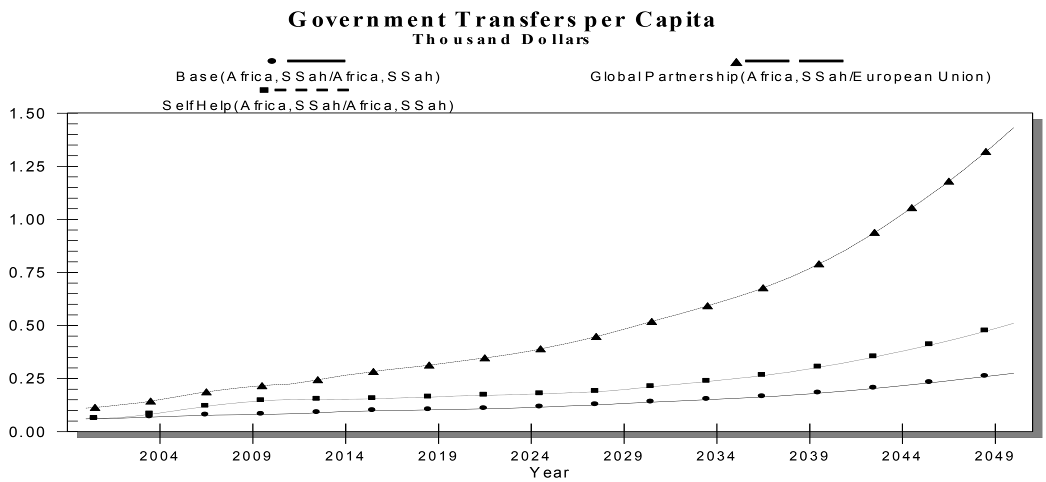


Figure 5.4 Social Transfers of Sub-Saharan Africa

Figure 5.5 explores about the implications of the three scenarios for the level of the UNDP's Human Development Index (HDI). Again, there are striking aspects of the figure. First, the Base Case and Self Help scenarios show now real increase in the HDI before 2020 and suggest a decrease in the second decade of the century. This is, of course, a result of the AIDS epidemic. Improvement by 2020 depends heavily on an assumption in the Base Case that the epidemic will be coming under control by then. Second, the Self-Help scenario is no better than the Base Case, in fact it is very marginally worse. Only the Global Partnership begins to improve conditions significantly.

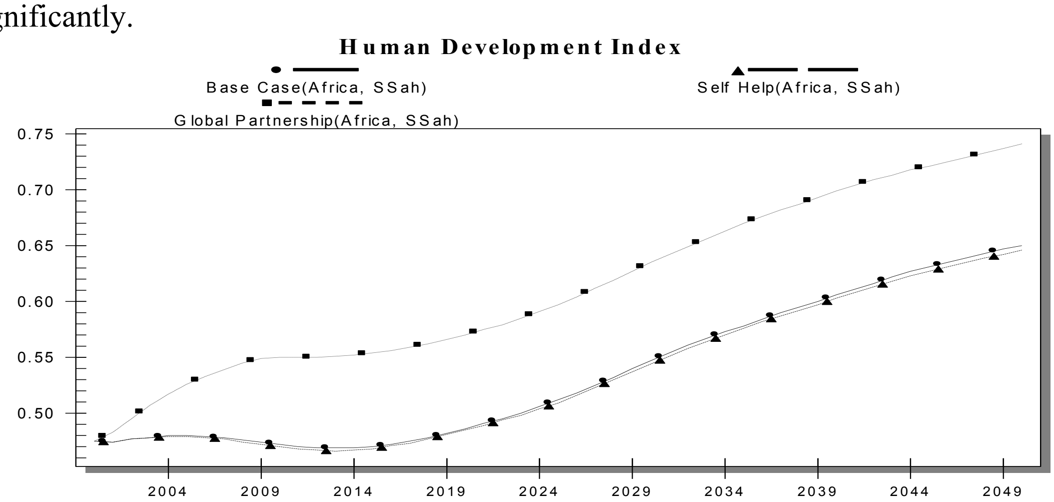


Figure 5.5 HDI of Sub-Saharan Africa

Figure 5.6 provides elaborating information concerning the failure of the Self Help scenario to improve average well-being, as measured by GDP per capita. Note that the Self-Help scenario actually lowers the GDP per capita very marginally compared to the Base Case. The reason is likely the crowding out of investment and growth by the extra government spending.

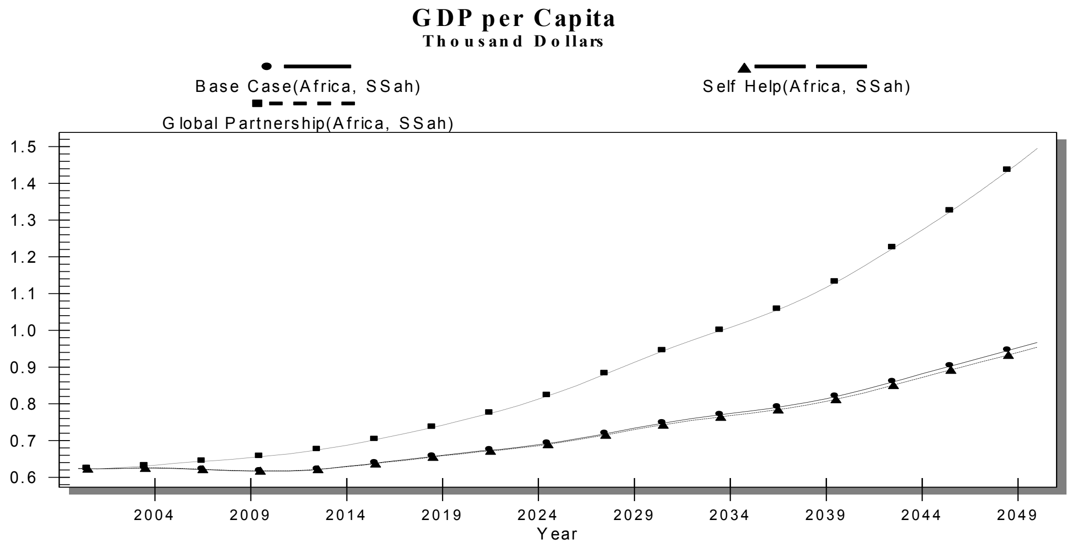


Figure 5.6 GDP per Capita of Sub-Saharan Africa

The impacts on HDI and GDP do not mean, however, that the Self-Help scenario is definitively inferior to the Base Case. Figure 5.7 shows that the household income of unskilled workers, those who need it the most to escape poverty, is actually up a little relative to the Base Case. Nonetheless, there is no comparison in the impact of Self Help to the impact of the Global Partnership.

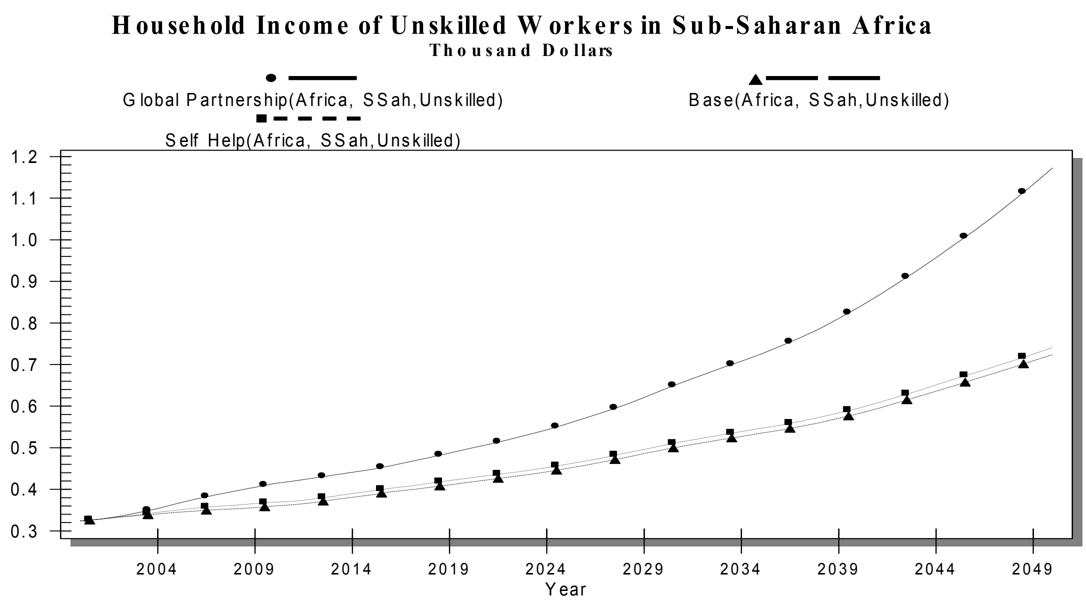


Figure 5.7 Household Income, Unskilled of Sub-Saharan Africa

Again, this analysis is a very preliminary one with a SAM structure that is still very much a work in progress. As that structure becomes more capable, the analysis will be pursued with many other questions in mind. How different is the Sub-Saharan case from that of Latin America or South Asia? What are the implications of more refined targeting of Self-Help (or funds from Global Partnership)? Might, for instance, spending on education be superior to spending on pensions in improving the HDI, especially in the longer term?

6. Conclusions

There is a great deal of work yet to be accomplished in implementing the universal SAM. In addition to refining the model generally and extending is use, there will be specific attention paid to completing the representation of international financial stocks and flows and analysis.

An integrated, long-term, global model can bring together representations of demographics, markets, domestic and international financial transfers, and much more. The addition of a universal SAM to the IFs package is a powerful tool for helping force accounting across financial transfers and for linking short-term flows to long-term consequences. There appears much to be gained from pursuing this line of development.

7. Bibliography

Alarcón, Jorge, Jan Van Heemst, and Niek de Jong. 2000. "Extending the SAM with Social and Environmental Indicators: an Application to Bolivia," Economic Systems Research 12, no. 4: 473-496.

Allen, R. G. D. 1968. Macro-Economic Theory: A Mathematical Treatment. New York: St. Martin's Press.

Barker, T.S. and A.W.A. Peterson, eds. 1987. *The Cambridge Multisectoral Dynamic Model of the British Economy*. Cambridge: Cambridge University Press.

Barro, Robert J. 1997. *Determinants of Economic Growth: A Cross-Country Empirical Study*. Cambridge: MIT Press.

Barro, Robert J. and Xavier Sala-i-Martin. 1999. *Economic Growth*. Cambridge: MIT Press.

Barro, Robert J. and Jong-Wha Lee. 2000. "International Data on Educational Attainment Updates and Implications, National Bureau of Economic Research Working Paper 7911, www.nber.org/papers/w7911 (September).

Bils, Mark and Peter J. Klenow. 2000 (March). Does Schooling Cause Growth? NBER paper.

Bongarts, John and Rodolfo A. Bulatao, eds. 2000. *Beyond Six Billion: Forecasting the World's Population.* Washington, D.C.: National Academy Press.

Brockmeier, Martina and Channing Arndt (presentor). 2002. Social Accounting Matrices. Powerpoint presentation on GTAP and SAMs (June 21). Found on the web.

Bussolo, Maurizio, Mohamed Chemingui and David O'Connor. 2002. A Multi-Region Social Accounting Matrix (1995) and Regional Environmental General Equilibrium Model for India (REGEMI). Paris: OECD Development Centre (February). Available at www.oecd.org/dev/technics.

Chenery, Hollis. 1979. *Structural Change and Development Policy*. Baltimore: Johns Hopkins University Press.

Commission on Macroeconomics and Health (CMH). 2001 (December). *MacroEconomics and Health: Investing in Health for Economic Development*, presented to Gro Harlem Brundtland, Director-General of the World Health Organization.

Dimaranan, Betina V. and Robert A. McDougall, eds. 2002. *Global Trade, Assistance, and Production: The GTAP 5 Data Base*. Center for Global Trade Analysis, Purdue University. Available at http://www.gtap.agecon.purdue.edu/databases/v5/v5_doco.asp.

Directorate of Intelligence, Office of Transnational Issues, Strategic Assessments Group. 2001 (February). *The Global Economy in the Long Term*. Washington, D.C.: Office of Transnational Issues.

Duchin, Faye. 1998. *Structural Economics: Measuring Change in Technology, Lifestyles, and the Environment*. Washington, D.C.: Island Press.

Easterly, William. 2001. *The Elusive Quest for Growth*. Cambridge: MIT Press.

Everstadt, Nicholas. 2002. "The Future of AIDS," *Foreign Affairs* 81, No. 6 (November/December): 22-45.

England, Robert Stowe. 2001. *The Fiscal Challenge of an Aging Industrial World*. Washington, D.C.: CSIS Press.

England, Robert Stowe. 2002. *Global Aging and Financial Markets: Hard Landings Ahead?* Washington, D.C.: CSIS Press.

Foley, Duncan K. and Thomas R. Michl. 1999. *Growth and Distribution.* Cambridge: Harvard University Press.

Hammond, Allen. 1998. *Which World? Scenarios for the 21st Century*. Washington, D.C.: Island Press.

Hashimoto, Ryutaro, Walter F. Mondale, and Karl Otto Pöhl, 2002. *Meeting the Challenge of Global Aging*. Washington, D.C.: CSIS Press.

Holzmann, Robert and Steen Jørgensen. 2000. Social Risk Management: A New Conceptual Framework for Social Protection, and Beyond." World Bank Social Protection Discussion Paper No. 0006 (February). Available at http://www1.worldbank.org/sp/.

Hughes, Barry B. 1987. "Domestic Economic Processes," in Stuart A. Bremer, ed., *The Globus Model: Computer Simulation of Worldwide Political Economic Development* (Frankfurt and Boulder: Campus and Westview), pp. 39-158.

Hughes, Barry B. 1997. "Rough Road Ahead: Global Transformations in the 21st Century," *Futures Research Quarterly* 13, No. 2 (Summer): 83-107.

Hughes, Barry B. 1999. *International Futures: Choices in the Face of Uncertainty*, 3rd ed. Boulder, Co: Westview Press.

Hughes, Barry B. 2001. "Global Social Transformation: The Sweet Spot, the Steady Slog, and the Systemic Shift," *Economic Development and Cultural Change* 49, No. 2 (January): 423-458.

Hughes, Barry B. 2002. "Sustainability Analysis Using the International Futures (IFs) Modelling System," prepared for a "conversation on sustainability…" sponsored by the Initiative for Science and Technology for Sustainability, the Global Scenario Group of the Stockholm Environmental Institute, and the project on Systems of Integrated Research, Assessment, and Decision Support for Global Environmental Change (SIRAD) at Harvard University. Boston, July 11-13, 2002.

Inglehart, Ronald. 1997. *Modernization and Postmodernization*. Princeton: Princeton University Press.

Jorgenson, Dale W. and Kevin J. Stiroh. 2000. "Raising the Speed Limit: U.S. Economic Growth in the Information Age," *Brookings Papers on Economic Activity* 1: 125-235.

Kaivo-oja, Jari, Jyrki Luukhanen, and Pentti Malaska (2002). "Methodology for the Analysis of Critical Industrial Ecology Trends: an Advanced Sustainability Analaysis of the Finnish Economy." Turku, Finland: Finland Futures Research Centre, unpublished manuscript.

Kehoe, Timothy J. 1996. Social Accounting Matrices and Applied General Equilibrium Models. Federal Reserve Bank of Minneapolis, Working Paper 563.

Kemp-Benedict, Eric, Charles Heaps, Paul Raskin. 2002 (March). Global Scenario Group Futures: Technical Notes. Boston: Stockholm Environmental Institute, Tellus Institute. PoleStar Series Report no. 9.

Khan, Haider A. 1998. Technology, Development and Democracy. Northhampton, Mass: Edward Elgar Publishing Co.

Lee, Ronald and John Haaga. 2002. *Government Spending in an Older America*. Washington, D.C.: Population Reference Bureau.

Maddison, Angus. 1995. *Monitoring the World Economy 1820-1992*. Oxford: Oxford University Press.

Maddison, Angus. 2001. *The World Economy: A Millennial Perspective*. Paris: OECD.

McMahon, Walter W. 1999. *Education and Development: Measuring the Social Benefits*. Oxford: Oxford University Press.

O'Neill, Brian and Deborah Balk. 2001 (September). *World Population Futures*, Population Bulletin 56, No. 3

Organization for Economic Cooperation and Development (OECD). 1996. *Ageing in OECD Countries: A Critical Policy Challenge*. Paris: OECD.

Organization for Economic Cooperation and Development (OECD). 2001. *The Well-Being of Nations: The Role of Human and Social Capital*. Paris: OECD.

Orszag, Peter R. and Joseph E. Stiglitz. 1999. "Rethinking Pension Reform: Ten Myths About Social Security Systems," presented at the World Bank Conference on "New Ideas about Old Age Security," September 14-15. Available at http://www.worldbank.org/knowledge/chiefecon/conferen/papers/rethinking.pdf.

Pan, Xiaoming. 2000 (January). "Social and Ecological Accounting Matrix: an Empirical Study for China," paper submitted for the Thirteenth International Conference on Input-Output Techniques, Macerata, Italy, August 21-25, 2000.

Pesaran, M. Hashem and G. C. Harcourt. 1999. Life and Work of John Richard Nicholas Stone. Available at http://www.econ.cam.ac.uk/faculty/pesaran/stone.pdf.

Pritchett, Lant. 1999 (December 21). "Where Has all the Education Gone?" World Bank paper.

Pyatt, G. and J.I. Round, eds. 1985. *Social Accounting Matrices: A Basis for Planning*. Washington, D.C.: The World Bank.

Qu Weishuang and Gerald Barney. 2001. "The Threshold 21 Integrated Development Model: Documentation for Version 3.0," unpublished paper from the Millennium Institute, Arlington, VA.

Raskin, P., T. Banuri, G. Gallopín, P. Gutman, A. Hammond, R. Kates, and R. Swart. 2001. *Great Transition: The Promise and Lure of the Times Ahead*. Forthcoming (see http://www.gsg.org/Initiatives/BTC01/Data/BTC01_data.htm).

Robinson, Sherman and Moataz El-Said. 2000 GAMS Code for Estimating a Social Accounting Matrix (SAM) with Cross Entropy Methods (CE).TMD Discussion Paper No. 64. Washington, D.C.: IFPRI.

Romer, Paul. 1994. "The Origins of Endogenous Growth." *Journal of Economic Perspectives* 8, no. 1 (Winter): 3-22.

Sala-i-Martin, Xavier. 2002 (April). "The Disturbing 'Rise' of Global Income Inequality," NBER Working Paper No. w8904. www.nber.org/papers/w8904.

Sala-i-Martin, Xavier. 2002 (May). "The World Distribution of Income (estimated from Individual Country Distributions," NBER Working Paper No. w8933. www.nber.org/papers/w8933.

Sen, Amartya. 1992. *Inequality Re-examined*. Cambridge: Harvard University Press.

Solow, Robert M. 1957. "Technology Change and the Aggregate Production Function," *Review of Economics and Statistics* 39: 312-320 This was the Nobel Memorial Lecture of 1984..

Stone, Richard. 1986. "The Accounts of Society," *Journal of Applied Econometrics* 1, no. 1 (January): 5-28

Thorbecke, Erik. 2001. "The Social Accounting Matrix: Deterministic or Stochastic Concept?", paper prepared for a conference in honor of Graham Pyatt's retirement, at the Institute of Social Studies, The Hague, Netherlands (November 29 and 30). Available at http://people.cornell.edu/pages/et17/etpapers.html.

United Nations Development Programme (UNDP). 2001. *Human Development Report 2001: Making New Technologies Work for Human Development*. New York: Oxford University Press.

United Nations Development Programme (UNDP). 2002. *Human Development Report 2002: Deepening Democracy in a Fragmented World*. New York: Oxford University Press.

Welzel, Christian, Ronald Inglehart, and Hans-Dieter Klingemann. 2001. "Human Development as a General Theory of Social Change: A Multi-Level and Cross-Cultural Perspective," Berlin: Wissenschaftzentrum Berlin FS III 01-201.

World Bank. 1994. *Averting the Old Age Crisis: Policies to Protect the Old and Promote Growth*. Oxford: Oxford University Press.

World Bank. 2000. *Social Protection Strategy Paper*. Washington, D.C.: World Bank. Available at http://www1.worldbank.org/sp/.