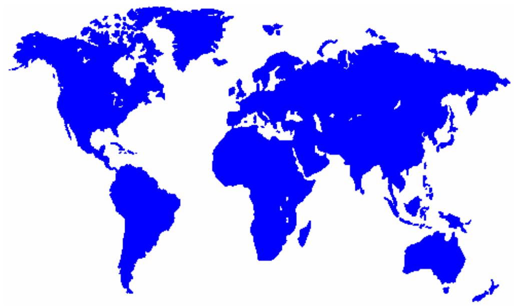

Long-Term Socio-Economic Modeling

With Universal, Globally-Integrated Social Accounting Matrices (SAMs) in a General Equilibrium Model Structure

Barry B. Hughes and Anwar Hossain
University of Denver
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Abstract

The International Futures (IFs) modeling project is built around a long-term, many country/region model of multiple interacting global systems. The time horizon can extend to 2100 and the countries/regions represented can be flexibly drawn from an extensive data base for 164 countries. The global systems include a cohort-component representation of demographic systems; a multi-sector, general equilibrium-seeking representation of economies integrated with a social accounting system; a module of formal education at primary, secondary, and tertiary levels; and other subsystems around energy, agriculture, domestic socio-political structures, interstate interaction, and the environment. The user-friendly, menu-driven interface of 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 pursuit of a globally sustainable future.

The purposes of this document are two. The first is to document part of the IFs model, specifically the socio-economic subsystems as represented by an equililbrium-seeking economic model integrated with a newly emergent macro social accounting framework. Elements of this modeling structure that collectively make it rather unique include:

- A six-sector goods and services market core with an equilibrium-seeking structure
- Technology matrices that vary with development level
- Macro (2 household type) social accounting matrices for up to 164 countries
- Representation of stocks behind the SAMs as well as flows, so as to facilitate dynamic representation
- Full integration globally of interstate financial flows within a general equilibrium structure

Because the SAM structures are relatively new to IFs, this paper will focus heavily on their documentation and use.

The second purpose of the paper is to present some analysis with the full IFs system that focuses on social support systems. Specific issues around human development that such a modeling system can help investigate range widely. They include, for instance, both the effort to create basic social safety nets or social protection systems throughout the developing world and the unfolding pension crises of many developed countries. Although this paper illustrates such analysis, extended treatment will follow in future revisions and other documents.

1. Introduction: Analysis Purposes

The broad purpose of the International Futures (IFs) modeling 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] With respect to human development, such futures can range from rapidly advancing human capabilities in even the poorest countries to deterioration of the human condition in even the richest.

Two examples of change in the human condition can illustrate more concretely the range of possible futures. The first focuses on the poorest of the poor and the second on the continued well-being of those who have reached a much higher level of human development.

The Millennium Summit's Development Goals (declared in September, 2000) are only a recent set within a long series of efforts to state objectives for addressing poverty in LDCs. The summit's summary statement is, nonetheless, very important and focuses our attention sharply on human development: "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." The Millennium Development Goals (MDG) that have grown out of this declaration all have clearly measurable and specific targets.

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 creation of social safety nets, focusing sometimes on assuring basic levels of income for all and

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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. In addition, the European Union Center at the University of Michigan has provided 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. Most recently, the RAND Frederick S. Pardee Center for Longer Range Global Policy and the Future Human Condition has begun to motivate and sponsor this work. 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, modeling, and programming support of the most recent model generation, and to earlier student colleagues (again see the Help system).

sometimes on specific targets such as food for children, relief for the unemployed, or adequate pensions for the retired.

In addition to the proactive impetus for attention to social safety nets and human development that has long come from the United Nations, the World Bank and many other actors, there is also an increasing impetus for attention that has come from the critics of globalization. Those critics, including respected scholars such as Rodrik (1997) and Stiglitz (2002), have pointed with increasing urgency to the potential that globalization processes can undercut efforts to enhance social safety nets and, in some cases, lead to weakening of those systems already in place. Even the greatest supports of globalization processes, including the International Monetary Fund and *The Economist,* have increasingly recognized the threats to human support systems and the need for protection of them.[2]

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 generation/provision of basic levels of income and social support in a growing economy and a developing socio-political system.

More economically-developed countries have their own issues around human development. One such issue is the re-organization of educational systems in the face of the emergent global knowledge-based economy. Another, however, is the funding of pension plans in the face of rapidly aging populations, an issue that threatens current social safety nets and human condition. 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.

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

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[2] 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. *The Economist* devoted a special section in its issue of May 3, 2003, to "A Cruel Sea of Capital."

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.

Two issues 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 employed workers and the larger population.

This working paper will return illustratively to these issues in the final chapter. Its primary purpose, however, is to document a methodology that will help address a great many issues around social support for human development. Specifically, the methodology is a universal and globally-integrated representation of social accounting matrices within the International Futures modeling system, including its equilibrium-seeking economic.

2. General Characteristics of the Approach

Analysis of long-term social change, including addressing of problems such as those identified in Chapter 1, 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. This chapter provides a brief introduction to the International Futures (IFs) modeling system and then turns to the development of Social Accounting Matrices (SAMs) within it. Although IFs includes a broader representation of domestic socio-political systems that is sketched below, SAMs represent an important recent extension of the IFs system that facilitates socio-economic analysis.

2.1 The IFs Modeling 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 modeling 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 modeling 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[3] 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) modeling 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

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[3] Within the TERRA project Mihajlo Mesarovic has placed particular stress on the necessity of making dominant relations clear within integrated modeling structures.

the third generation see Hughes (1999). Here we provide only very basic summary information on the structure of the system, 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 modeling system. The extensive data base underlying it includes data for 164 countries over as much of the period since 1960 as possible. The modeling 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.

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.

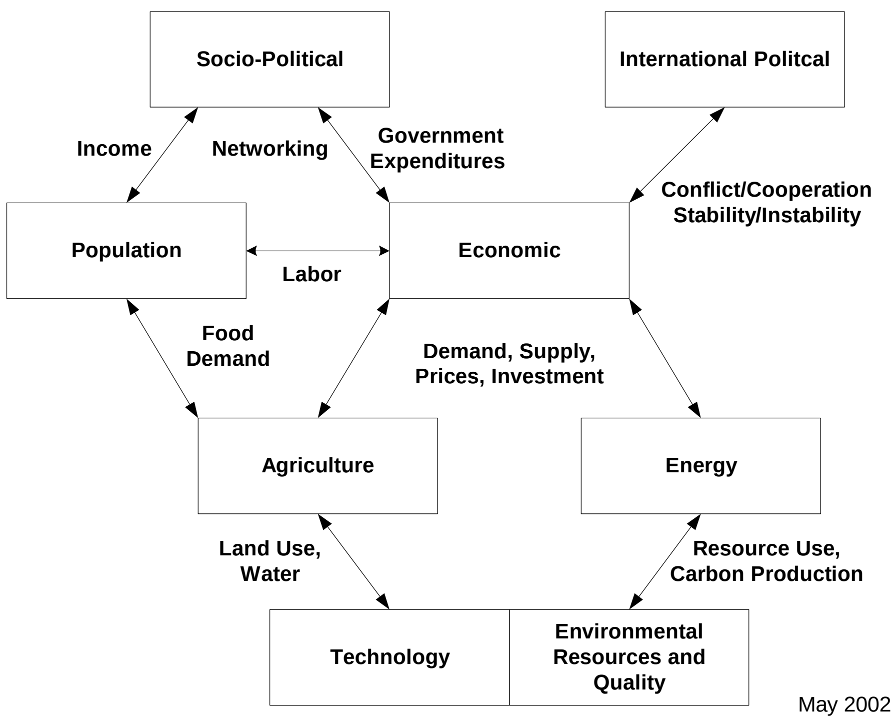

Figure 2.1 An Overview of International Futures (IFs) for TERRA

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 implicit technology module:

- is distributed 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

2.2 The Philosophy and Methodological Approach of IFs

The submodules of IFs are not simply collections of equations. Instead, there are strong structural foundations for those equation sets. IFs draws upon techniques found in both econometric and systems dynamics traditions, but also reaches beyond those, especially in its structural representations. The emergent methodological approach of IFs can be called "Structure-Based and Agent-Class Driven Modeling." That modeling approach has five key elements methodologically: organizing structures, stocks, flows, key aggregate relationships, and key agent-class behavior relationships.

Table 2.1 provides more detail, focusing on three sub-systems within IFs. The structural representations of those sub-systems are cohort-component systems for population, markets for production, exchange, and consumption of goods and services, and social accounting matrices (SAMs) for financial flows. In general, the structural foundations for all modules draw upon a varying combination of accounting system and equilibrating system elements for the structures. For example, the cohort-component structure is primarily an accounting system; markets and SAMs combine accounting systems with equilibrating ones.

It will be useful to elaborate somewhat on the approach to demographic modeling and to use that elaboration as a basis for turning to social accounting matrices. Demographers have widely accepted the representation of demographic systems and the development of demographic models with cohort-component structures. Those structures have a standard form, normally representing 5-year cohorts of population differentiated by sex in three basic ways: by numbers in the age-sex cohorts, by fertility rates in them, and by mortality rates in them. In fact, the United Nations, the U.S. Census Bureau, and the International Institute for Applied Systems Analysis (IIASA), perhaps the three pre-eminent demographic forecasting institutions, all use cohort-component modeling (O'Neill and Balk 2001).

System/Subsystem	Demographic	Goods and Services	Financial
Organizing Structure	Cohort-Component	Equilibrium-seeking Market	Market plus Socio-Political Transfers and Exchange (SAM)
Stocks	Population by Age-Sex	Capital, Labor, Accumulated Technology	Government, Firm, Household Assets/Debts
Flows	Births, Deaths, Migration	Production, Consumption, Trade, Investment	Savings, FDI, Foreign Aid, IFI Credits/Grants, Government Transfers (pensions and other social expenditures)
Key Aggregate Relationships (Illustrative, not Comprehensive)	Life Expectancy (including HIV/AIDS) With Exogenous Technological Assumptions	Production Function with Endogenous Technological Change	Exchange Rate Movements With Net Asset/Current Account Levels
Key Agent-Class Behavior Relationships (Illustrative, not Comprehensive)	Household Fertility and Migration	Households and Work/Leisure, Consumption, and Female Participation Patterns; Firms and Investment; Government and Direct Expenditures	Household Savings/Consumption; Firm Investment/Profit Returns and FDI Decisions; Government Revenue, Expenditure/Transfer Payments; IFI Credits and Grants

Table 2.1. Structure and Agent-Class Modeling of Demographics, Markets, and Financial Systems.

The second and third elements in Structure-Based, Agent-Class Driven modeling are stocks and flows, which may remind many readers of systems dynamics. In demographic systems, the stocks are numbers of people in age- and sex-specific cohorts, while the flows are births, deaths, and migration. Systems dynamics would deal with the key relationships as auxiliaries, but econometrics would recognize them as equations that require empirical estimation. Table 1 divides them into two categories: Key Aggregate Relationships (potentially represented multiple agents) and Key Agent-Class Behavioral Relationships. Life expectancy or mortality is a key aggregate relationship, clearly a function of income, perhaps education, and certainly of technological change. In contrast, fertility can be described as an agent-class behavioral relationship. In the case of fertility, there is one primary agent-class, namely households, whose behavior, as a function again of income, education, and technology, will change over time. Key Aggregate Relationships are often actually Agent-Class behaviors that have not yet been decomposed enough to represent in terms of specific agent classes. For instance, life expectancy is clearly a function of government and firm spending on R&D as well as household life-style choices; it could eventually be decomposed to the agent-class level.

It is important to say more about the emphasis placed on agent-class representations. First, they are important because they begin to represent elements amenable to human decision-making/choice. Ideally we would want all key relationships decomposed to that level, but doing so is a gradual process. Second, they truly are agent-class representations, to be differentiated from the micro agents of agent-based modeling. Although micro-agent modeling is laudable in more narrowly-focused models, global systems and structures are far too numerous and well-developed for such efforts to succeed across the breadth of concerns in world models, at least given contemporary modeling capabilities. Instead we focus on primary agent classes, especially households, firms, and governments, taking structures as given, albeit malleable, rather than emergent.[4]

In terms of the comments above, the cohort-component structure is a deep theoretically-based kernel of the demographic model, one which would seldom be altered in an open environment. In contrast, both key aggregate and agent-driven relationships should ideally be completely accessible to users for their replacement with theoretically and empirically stronger versions.

The second systemic and structural element in Table 1 is that of markets in goods and services, which most larger-scale models, including IFs, represent with some variation of general equilibrium model structure. Again there are obvious stock and flow components of markets that are desirable and infrequently changed in model representation. Perhaps the most important key aggregate relationship is the production function. Although the firm is an implicit agent-class in that function, the relationships of production even to capital and labor inputs, much less to the variety of technological and social and human capital elements that enter a specification of endogenous productivity change (Solow

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[4] Debates around the relationships of structures and agents pervade all social sciences. In general, the literatures conclude that the two are mutually formative. Although there will normally be more dynamism in agent-class behaviour than in structures, it is important to recognize that structures also change.

1957; Romer 1994), involve multiple agent-classes. In the representation of the market now in IFs there are also many key agent-class relationships as suggested by Table 1.

The third systemic and structural element in Table 1 is financial flows, including those related to the market (like foreign direct investment), but extending also to those that have a socio-political basis (like government to household transfers). Once again, an increasingly widely-accepted approach to structural representation is the Social Accounting Matrix (SAM).

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 or SNA (see Pesaran and Harcourt 1999 on Stone's work and Stone 1986). 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 or SEAMs (see Pan 2000). Another very productive extension is into the connection between SAMs and technological systems of a society (see Khan 1998; Duchin 1999).[5] 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.

Once again, the structural system portrayed by SAMs is well represented by stocks, flows, and key relationships.[6] Although the traditional SAM matrix itself is a flow matrix, IFs has introduced a parallel stock matrix that captures the accumulation of assets and liabilities across various agent-classes. The dynamic elements that determine the flows within the SAM involve key relationships, such as that which constrains government spending or forces increased revenue raising when government indebtedness rises. Many of these, as indicated in Table 1 represent agent-class behavior.

2.3 Dynamic Modeling of Markets and SAMS

In essence, this structural representation is a variant and to some degree an extension of the computable general equilibrium formulations that often surround SAMs. Again, Stone was a pioneer, leading the Cambridge Growth Project with Alan Brown. That project placed SAMs into a broader modeling framework so that the effects of changes in

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[5] 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.

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

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 five 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. Jansen and Vos (1997: 400-416) refer to such aggregated systems as using a "Macroeconomic social Accounting Framework." Each SAM has an identical structure and they can therefore be easily compared or even aggregated (for regions of the world). See the basic structure in Table 2.2.

		Commodities	**Household**		**Firms**	**Capital**		**Government**		**ROW**		**Total**
			Unskilled	**Skilled**								
Commodities		AX	Household Consumption	Household Consumption		Gross Fixed Capital Formation	Changes in Inventories	Government Consumption		Exports		**To Dem**
Household	Un	Value Addition			Dividends/Interest			SS Benefit	Pension	Share of Income Receipts (Workers' compensation)		**Hous Inc**
	Skill	Value Addition			Dividends/Interest			SS Benefit	Pension, Interest			**Hous Inc**
Firms		Value Addition						Subsidy to Firms	Interest	FDI inflows Portfolio Investment, Equity inflows Share of Income Receipts (Investment income)		**Fi Inc**
Capital			Household Savings	Household Savings	Firm Savings			Government Savings		Foreign Savings (Outflow-Inflow)		**Dom and F inves**
Government			Income Taxes	Income Taxes	Corporate/Business Taxes					Foreign Aid	WB Loan Receipts	**Gover Rev**
			SS Taxes	SS Taxes	SS Taxes					Portfolio Invt, Bond	IMF credit Receipts	
					Taxes on goods and Services (Indirect Taxes)					Interest	Loans from Other IFIs	

		Commodities	Household		Firms	Capital	Government	ROW	Total
			Unskilled	**Skilled**					
ROW		Imports	Share of Income Payments (Workers' compensation)		Share of Income Payments (Investment Income)		Foreign Aid		**Exte Fl (Out**
					FDI Outflows		PPG Debt Service (Int + Principal)		
							WB Loan Repayment		
							IMF Credit Repayment		
							Other IFIs		
Total		**Total Supply**	**Household Expenditures**		**Firm Expenditures**	**Investment**	**Government Expenditures**	**External Flows (Inflow)**	

Table 2.2 Basic SAM Structure: Flows

The second extension is the connecting of the universal set of SAMs through representation of the global financial system. Most SAMs treat the rest of the world as a residual category, unconnected to anything else. Because IFs contains SAMs for all countries, it is important that the rest-of –the-world categories are mutually consistent. Thus exports and imports, foreign direct investment inflows and outflows, government borrowing and lending, and many other inter-country flows must be balanced and consistent.

The third extension is a representation of stocks as well as flows (see Table 2.3). Both domestically and internationally, many flows are related to stocks. For instance, foreign direct investment inflows augment or reduce stocks of existing investment. Representing these stocks is very important from the point of view of understanding long-term dynamics of the system because those stocks, like stocks of government debt, portfolio investment, IMF credits, World Bank loans, reserve holdings, and domestic capital stock invested in various sectors, generate flows that affect the future. Specifically, the stocks of assets and liabilities will help drive the behavior of agent classes in shaping the flow matrix.

The IFs stock framework has been developed with the asset-liability concept of standard accounting method. The stock framework is also an extension of the social accounting flow matrix, and the cumulative flows over time among the agents will determine the stocks of assets or liabilities for all agents. If the inflow demands repayment or return at some point in future, it is considered as liability for that agent and an asset for the agent from which the flow came. For example, in the IFs framework, if a government receives loans (inflow) from other countries, the stock of those loans is a liability for the recipient government and an asset for the country or countries providing the loans.

The matrix below shows the structure of the SAM stock matrix, most of which has now been implemented. We have tried to maintain consistency between the stock and flow matrices. When we read a particular cell, the figure is an asset for the corresponding column agent, while it is liability for the corresponding row agent.

Asset ⇒ Liab ⇓	Commodities	Household	Firms	Capital	Government	
	Assets					
Commodities	Liabilities			Capital Stock		
Household						
Firms		Corporate Bonds/Debentures; Corporate Equity				Private Nonguarante
Capital		HH accumulated Savings	Firms' accumulated Savings		Public Sector Inv/ Govt accumulated Savings	Foreig
Government		Government Bonds	Government Bonds			Exter; Short Te; Concessional; NonC; Debt with WI
ROW			Private non guaranteed debt; FDI to ROW; Portfolio Invt, Equity to ROW; Portfolio Invt, Bond to ROW		Lending to ROW: Short Term (accumulated), Long Term (accumulated); Foreign Currency Reserves: Central Bank, WB, IMF	
Total	**Commodities**	**Household**	**Firms**	**Investment**	**Government**	

Table 2.3 Basic SAM Structure: Stocks

The fourth extension is temporal and builds on the third. The SAM structure described here has been embedded within a long-term global model. The economic module of IFs has many of the characteristics of a typical CGE, but the representation of stocks and related agent-class driven behavior in a consciously long-term structure introduces a quite different approach to dynamics. Instead of elasticities or multipliers on various terms in the SAM, IFs seeks to build agent-class behavior that often is algorithmic rather than automatic. To clarify this distinction with an example, instead of representing a fixed set of coefficients that determine how an infusion of additional resources to a government would be spent, IFs increasingly attempts partially to endogenize such coefficients, linking them to such longer-term dynamics as those around levels of government debt. Similarly, the World Bank as an actor or agent could base decisions about lending on a wide range of factors including subscriptions by donor states to the Bank, development level of recipients, governance capacity of recipients, existing outstanding loans, debt-to-export ratios, etc. Much of this kind of representation is in very basic form at this level of development, but the foundation is in place.

The fifth and final extension has already been discussed. In addition to the SAM, IFs also includes a number of other submodels relevant to the analysis of longer-term forecasts. For example as discussed above, 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.

2.4 Creating and Initializing the SAMS: The Preprocessor

Preparing an initial data load for a model sometimes requires almost as much work as does creating and maintaining the dynamics of the model. Data inconsistency and data holes require attention; in a model like IFs with physical representations of partial equilibrium sectoral models (agriculture and energy) as well as a general equilibrium multi-sector model represented in value terms, there is the also the need to reconcile the physical and value data.

Creation of a data pre-processor within IFs moved the project from manual handling of issues around data loads to automatic, algorithm-based processing. The pre-processor greatly facilitates both partial data updates as better data become available and rebasing of the entire model to a new initial year (such as the rebasing from 1995 to 2000). It works with an extensive raw data file for all areas of the model, using data gathered for 1960 through the most recent year available. This allows it to create an historic data load (based in 1960) for the purposes of historic validation analysis, as well as the load for forecasting.

It is not the purpose of this paper to fully document the pre-processor, but a summary description is important. In general, the pre-processing begins with demographics, and imposes total population data on the cohort-specific data by normalizing cohort numbers to the total. The pre-processor reads values for a wide range of population-related variables: total fertility rate, life expectancy, HIV infection rate, literacy rate, etc. IFs uses cross-sectionally estimated relationships to fill holes in such data (generally with separate functions for the 1960 and 2000 data loads). Most often, functions driven by GDP per capita at PPP have had the highest correlations with existing data; the best functions have often been logarithmic, because the most rapid structural change occurs at lower levels of GDP per capita (Chenery 1979). The philosophy in demographics and in subsequent issue areas in the pre-processor is that values for all 164 countries in IFs will come from data when it is available, but will be estimated when it is not.

The pre-processor then proceeds to the agricultural and energy issue areas. In agriculture, the pre-processor reads data on production and trade. It aggregates production of various crops into a single crop production variable used by the model. It similarly aggregates meat and fish production for the model. It computes apparent consumption. It reads data on variables such as the use of water and on the use of grain for livestock feed. It uses estimated functions or algorithms to fill holes and to check consistency (for instance, checking grain use against livestock herd and grazing land data).

In energy, the pre-processor reads and converts energy production and consumption to common units (billion barrels of oil equivalent). It checks production and reserve/resource data against each other and adjusts reserves and resources when they are inconsistent. Null/missing production values are often overridden with a very small non-zero value so that a "seed" exists in a production category for the subsequent dynamics of the model (a technique used by the Interfutures model of the OECD). World energy exports and imports are summed; world trade is set at the average of the two and country-specific levels are normalized to that average.

The outputs from processing of agricultural and energy data become inputs to the economic stage of pre-processing. The economic processing begins by reading GDP at both exchange rates and purchasing power and saving the ratio of the two for subsequent use in forecasting. The first real stages of economic data pre-processing center on trade. Total imports and exports for each country are read; world sums are computed and world trade is set at the average of imports and exports; country imports and exports are normalized to that global average. The physical units of agricultural and energy trade are read and converted to value terms. Data on materials, merchandise, service, and ICT trade are read. Merchandise trade is checked to assure that it exceeds food, energy, and materials trade, and manufactures trade is identified as the residual. All categories of trade are normalized. When this process is complete, the global trade system will be in balance. The use in IFs of pooled trade rather than bilateral trade makes this easier, but a similar process could be used for bilateral trade with Armington structures.

The processes for filling the SAM with goods and services production and consumption, and with financial flows among agent-classes follow next. They are the subject matter of the subsequent pages of this documentation.

After the cleaning and reconciliation of data and the filling of holes, the pre-processor aggregates data from the 164 countries into the specified regionalization of the world, a combination of countries/regions. The student edition provides a total of under 20 countries/regions. The professional edition provides up to 65. There is also a full 164-country version with no aggregation. Aggregation approach is variable-specific with four variations: sum, simple average, population-weighted average, and GDP-weighted average. The variable definition file of IFs specifies the appropriate variation for each variable.

Subsequent chapters will comment as necessary on the setting of initial values for elements in the SAM.

2.5 Documentation Notation and Special Functions

As a general rule, the equations closely follow the computer code. Insofar as possible without confusion, variable and parameter names here are the same as those in the computer program, but in a few cases equation names differ to enhance readability. Computer code shows a single computed variable on the left and one or more input variables and parameters on the right. In fact, computer code frequently shows the computed variable on both the left and the right hand side, which is NOT standard mathematical equation form and a few traditional purists have difficulty understanding this (as well as preferring non-mnemonic single letter variable names and Greek symbols to much more intelligible computer-based variable names). As an appropriate accommodation, this documentation sometimes uses asterisks to distinguish different values of the same variable name on left and right-hand sides of equations.

Variable names are shown in all capitals, as in the display functions of the model. Parameters are shown in lower case and boldface. Empirically-based initial conditions of variables are in capitals with boldface. Internal computed variables, which are not available for display, are shown in mixed upper and lower case.

Superscripts other than "t" indicate exponentiation. Superscripts with "t" indicate time, but may be omitted when a reference is contemporary to year "t."

Subscripts show dimensionality and there are a number of standard ones in the model:

r	region/country	r = 1,2,... (e.g., United States, European Union, Japan, Brazil…)
c	age cohort	c = 1,2,...,22 (infant, 0-4 years,... 95-99 years, 100+ years; abbreviated set for WVS variables)
s	economic sector	s = 1,2,3,4,5,6 (agriculture, energy, materials, manufactures, services, ICT)
f	food types	f = 1,2 (crops, meat/fish)
l	land types	l = 1,2,3,4,5 (crop, grazing, forest, unused, urban/industrial)
e	energy types	e = 1,2,3,4,5,6,7 (oil, gas, coal, hydroelectric, nuclear, other renewable, unconventional oil)
g	govt spending	g = 1,2,3,4,5,6 (military, health, education, R&D, other, foreign aid)

Individual equations specify a range of dimensionality only if it differs from that above.

IFs has multiple modules: population, economic, agriculture, energy, and socio-political. An environmental "module" is scattered across other modules, especially agriculture and energy. Equations are presented by module and cross references in the documentation of each module indicate linkages.

IFs is a recursive dynamic system and equation sequence is therefore important. This text presents equations in largely the same sequence as in the computer program. Program flow exits from and returns to each module up to three times each time step (year), however, and it would break up discussions of module too much if we were to follow computational flow slavishly. Moreover, to facilitate understanding this documentation sometimes presents the key equations of a module or a section of one first, with subsequent explanation of the computational procedures for variables used therein (thereby deviating further from actual computation sequence). Equation form here is the same as in the computer program, including the presentation of a single "computed" variable on the left side of the equal sign.

Adjuster. In many modules, especially the economic module and the two elaborated sectoral modules, IFs relies upon an adjustment function to alter key variables (e.g., demand, prices, trade, and investment) in the pursuit of equilibrium. The adjustment function compares the level of some stock type variable (most often either inventory levels or prices, but including other variables such as international indebtedness) with a desired level, and adjusts the dependent variable.

IFs computes a difference (DIFF1) between the actual and desired levels and scales that difference with a scaling base (SCALINGBASE) value (for instance, total production in an economic sector might be a reasonable scaling base value against which to gauge the importance of a deviation of inventories from desired levels). In addition, the adjustment mechanism uses a second-order difference (DIFF2) to compare the level of the stock-type driving variable with its value in the previous time cycle, relying upon the same scaling base.

Non-zero differences result in a multiplier value (MUL) that deviates from “1” depending on the magnitude of two elasticities (EL1 and EL2). Specifically, the formulation is

$$MUL = \left(1 + \frac{DIFF1}{SCALINGBASE}\right)^{\boldsymbol{EL1}} * \left(1 + \frac{DIFF2}{SCALINGBASE}\right)^{\boldsymbol{EL2}}$$

This mechanism is represented in a function called the adjuster (ADJSTR) that the model calls at numerous locations. The magnitude of the two parameters will, of course, differ depending on the model variable in which equilibrium is being pursued. Experience has shown, however, that EL1 normally takes absolute values between 0.2 and 0.4, while EL2 is most often two times the value of EL1 and thus varies most often between 0.4 and 0.8. The values of EL1 and EL2 have been determined experimentally, in order to be large enough to maintain approximate equilibrium and small enough to avoid unreasonably rapid or extreme oscillation. There will inevitably be some oscillation in equilibrium-seeking processes, and in some cases (such as inventory levels), the values could be set so as to provide an oscillation consistent with known cycles (such as business cycles). Because IFs is a long-term rather than a short-term model, however, we have generally devoted little attention in scaling to the oscillation cycle, focusing instead on long-term stability in the face of shocks introduced by scenarios of model users. This kind of adjustment mechanism is sometimes called a PID controller, that is, an adjustment process that responds proportionately (the adjustment parameters) to the integral of the error (the stock discrepancy) and to the derivative of the error (the change in stock term). We shall see many PID controllers in IFs. For more information see the books by Chang (1961) and by Mishkin and Braun (1961) in the bibliography. An early version of this adjustment mechanism was developed by Thomas Shook for the Mesarovic-Pestel modeling project.

ConvergeOverTime. In the development of IFs it has been found that there are many instances in which initial empirical conditions for values in specific countries vary considerably from what one might expect in the longer-term. In some instances, data may be faulty. In others, there may be disequilibria that appear unlikely to be maintained over time or cultural distinctiveness that appears likely to erode. Because immediate readjustment of such values would both violate the integrity of the data and, in many cases, create other discrepancies, such adjustment is rare in IFs. Instead, the modeling system uses a mechanism to facilitate convergence over time of the values to a target computation that appears a reasonable longer-term expectation. The mechanism is used with sufficient frequency that it is built into a function with the name ConvergeOverTime, and that name returns a value to the program when it is called with three parameters: a base value that comes from the empirical side (Base), a target value that comes from forecasting relationships (Target), and a number of years over which the model should interpolate between the base and the target, converging with the target over that period (Years to Converge).

$$ConvergeOverTime = \frac{Base*(YearsToConverge - TimeFac) + Target*TimeFac}{YearsToConverge}$$

where

$$TimeFac = \text{Amin}(t, YearsToConverge)$$

AMAX and AMIN. IFs often bounds a variables computation with upper or lower limits. This serves a number of functions, all related to assuring reasonable behavior of the model under extreme conditions. For instance, denominators that might approach 0 are bound with the AMAX function so that they take on at least some specified number – the AMAX function returns the larger of the computed value and the number specified. Other computations are subject to the AMIN function so as to avoid becoming unreasonably large (such as probabilities that exceed 1) – the AMIN function returns the smaller of the computed value and the number specified.

AnalFunc and TablFunc. Throughout the IFs documentation there will also be references to analytic functions that have been added to the library of IFs functions. Because the user interface allows display and change of such functions, the form and parameters are not always elaborated in the written documentation. Some references to TablFunc persist in error from earlier versions of documentation when analytic functions were still represented as systems-dynamic like table functions, but an effort is being made to reserve TablFunc for the handful of functions that are still truly represented in such a manner. Occasionally an "F" creeps in, also referring to analytic functions in the library.

2.6 The Presentation to Follow

Documenting the combination of the general equilibrium model and the SAM is not simple, because of the very tight integration of all elements in the structure. The structural base of the SAM system within IFs has a strong accounting character, with requirements that flows balance within and across countries, and also that stocks of assets and liabilities balance. In addition, however, the dynamic representation of SAMs within IFs introduces the need for equilibrating elements within the underlying structure, just as single-country SAMs are traditionally integrated with CGE models.

In the case of IFs, there are two key equilibrating subsystems linked to the SAM structure. The first, elaborated in Chapter 3, is for the goods and services markets that bind together production, consumption, and exchange of goods and services. The production function is a key aggregate relationship in that sector, providing value added by sector, and being responsive to a range of variables including energy shortages and trade openness. In markets for goods and services, inventories and changes in capacity utilization serve buffering roles in the shorter-term, while changes in prices and investment patterns equilibrate markets in the longer-term.

The second equilibration subsystem, elaborated in Chapters 4-6, is for assets and liabilities. Each agent-class accumulates assets and liabilities over time and these, along with immediate income or revenues, determine their behavior. At this point in the elaboration of the SAM structure within IFs, there is no representation of equilibration processes for households and firms (Chapter 5), but there are representations for governments (Chapter 4) and for aggregate countries (Chapter 6) in the global financial system. The discussion in these chapters weaves together explanation of agent-class behavior and equilibrating systems.

Connecting the organization of this document more directly with the SAM, it makes sense to begin, in the next chapter with the goods and services market, which in many respects is the core of the economic model, as well as being the first row and column in the SAM structure. Specifically, Chapter 3 will discuss the supply and demand sides of the model first, moving then to equilibrating structures.

Chapters 4 -6 turn to key agent-classes within the SAM structure. Chapter 4 will discuss the receipts and expenditures of government and the equilibrating processes around maintaining longer-term balances of them. Chapter 5 turns to the private sector, households and firms. Chapter 6 moves to the Rest of the World (ROW) column and row, elaborating the extensive international financial linkages across the countries of the system, all of which tie into the equilibrating mechanisms around current and capital accounts.

The current version of this living document only begins the analysis activity with the system it describes, providing some introduction to use of the system in Chapter 7 and analysis with it of long-term social support of human development in Chapter 8.

3. The Goods and Services Market Foundation

The economics sub-model of IFs draws on two general modeling traditions. The first is the dynamic growth model of classical economics. Within IFs the growth rates of labor force, capital stock, and multifactor productivity largely determine the overall size of production and therefore of the economy. The second tradition is the general equilibrium model of neo-classical economics. IFs imbeds the production function in a six-sector (agriculture, raw materials, energy, manufactures, services, and ICT) equilibrium-seeking module that represents domestic supply, domestic demand, and trade. Further, the goods and services market representation is embedded in a larger social accounting matrix structure that introduces the behavior of household, firm, and government agent classes, including actions that shape inputs to the production function. This chapter describes the core goods and services market module. The following chapters move to the SAM and the more general equilibrium structure.

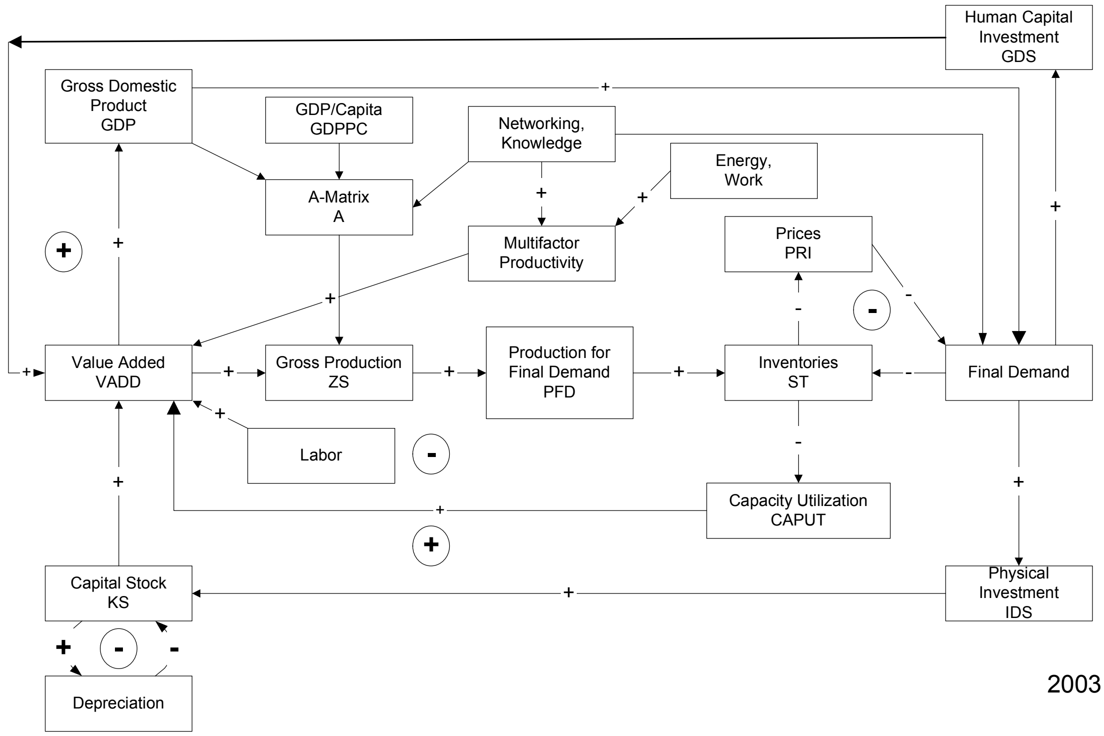
The growth portion of the goods and services module responds to endogenous labor supply growth (from the demographic model), endogenous capital stock growth (with a variety of influences on the investment level), and a mixture of endogenous and exogenous specification of advance in multifactor productivity (MFP). The endogenous portion of MFP represents a combination of convergence and country-specific elements that together create a conditional convergence formulation.

The equilibrium-seeking portion of the goods and services market module uses increases or decreases in prices (by sector) to balance demand and supply. Inventory stocks in each sector serve as buffers to reconcile demand and supply temporarily. Prices respond to stock levels. The central equilibrium problem that the module must address is maintaining balance between supply and demand in each of the sectors of the model. IFs relies on three principal mechanisms to assure equilibrium in each sector: price-driven changes in domestic demand; price-driven changes in trade; and stock-driven changes in investment by destination (changes in investment patterns could also be price-driven; IFs uses stocks because of its recursive structure, so as to avoid a 2-year time delay in the response of investment).

The economic sub-model makes no attempt through iteration or simultaneous solution to obtain exact equilibrium in any time point. Kornai (1971) and others have, of course, argued that real world economic systems are not in exact equilibrium at any time point, in spite of the convenience of such assumptions for much of economic analysis. Moreover, the SARUM global model (Systems Analysis Research Unit, 1977) and GLOBUS (Hughes, 1987) use buffer systems similar to that of IFs with the model "chasing" equilibrium over time.

Two "physical" or "commodity" sub-models, agriculture and energy, have structures very similar to each other and to the economic sub-model. They have partial equilibrium structures that optionally, and in the normal base case, replace the more simplified sectoral calculations of the goods and services market module. The Help system describes those sub-models and this documentation does not.

Figure 3.1 shows the basic structure of the goods and services market module. In presenting equations we will begin with supply and demand equations. Later subsections will detail elements of the equilibrating processes, namely trade, prices, and investment.



3.1 The Production Function for Value Added

Cobb-Douglas production functions involving sector-specific capital (KS) and labor (LABS) provide potential value added (VADDP) in each sector, taking into account the level of capacity utilization (CAPUT). In a multi-sector model the functions require sectoral exponents for capital (CDALFS) and labor that, assuming constant returns to scale, sum to one within sectors.

Solow (1956) long ago recognized that the standard Cobb-Douglas production function with a constant scaling coefficient in front of the capital and labor terms was inadequate because the expansion of capital stock and labor supply cannot account for most economic growth. It became standard practice to represent an exogenously specified growth of technology term in front of the capital and labor terms as "disembodied" technological progress (Allen, 1968: Chapter 13). Romer (1994) began to show the value of unpacking such a term and specifying its elements in the model, thereby endogenously representing this otherwise very large residual, which we can understand to represent the growth of productivity.

In IFs that total endogenous productivity growth factor (TEF) is the accumulation over time of annual values of growth in multifactor productivity (MFPGRO). There are many components contributing to growth of productivity, and there is a vast literature around them. See, for example, Barro and Sala-i-Martin (1999) for theoretical and empirical treatment of productivity drivers; also see Barro (1997) for empirical analysis (or McMahon 1999) for a focus on education.

In the development of IFs there was a fundamental philosophic choice to make. One option was to keep the multi-factor productivity function very simple, perhaps to restrict it to one or two key drivers, and to estimate the function as carefully as possible. Suggestions included focusing on the availability/price of energy and the growth in electronic networking and the knowledge society.

The second option was to develop a function that included many more factors known or strongly suspected to influence productivity and to attempt a more stylistic representation of the function, using empirical research to aid the effort when possible. The advantages of the second approach include creating a model that is much more responsive to a wide range of policy levers over the long term. The disadvantages include some inevitable complications with respect to overlap and redundancy of factor representation, as well as some considerable complexity of presentation.

Because IFs is a thinking tool, the second approach was adopted, and the production function has become an element of the model that will be subject to regular revision and, hopefully, enhancement. IFs groups the many drivers of multifactor productivity into five categories, recognizing that even the categories overlap somewhat. The base category is one that represents the elements of a convergence theory, with less developed countries gradually catching up with more developed ones. The four other categories incorporate factors that can either retard or accelerate such convergence, transforming the overall formulation into conditional convergence.

0. The convergence base. The base rate of multifactor productivity growth (MFPRATE) is the sum of the growth rate for technological advance or knowledge creation of a technological leader in the global system (mfpleadr) and a convergence premium (MFPPrem) that is specific to each country/region. The basic concept is that it can be easier for less developed countries to adopt existing technology than for leading countries to develop it (assuming some basic threshold of development has been crossed). The base rate for the leader remains an unexplained residual in the otherwise endogenous representation of MFP, but that has the value of making it available to model users to represent, if desired, technological cycles over time (e.g. Kondratief waves). The base also includes a correction term (MFPCor) that is initially set of the difference between empirical growth of MFP (calculated the first year as a residual between factor growth and output growth) and the sum of the technological leader and convergence premium terms. Over time, the correction term is phased out, but the four other terms, each of which is computed relative to the initial year, become key drivers of country-specific productivity. In fact, significant change in the other terms can either undercut the foundational convergence process or greatly augment it.

1. Knowledge creation and diffusion. On top of the foundation, changes in the R&D spending (CHGRANDD), computed from government spending (GDS) on R&D as a portion of total government spending (GOVCON) contribute to knowledge creation,

notably in the more developed countries (Globerman 2000 reviewed empirical work on the private and social returns to R&D spending and found them to be in the 30-40% range; see also Griffith, Redding, and Van Reenen 2000). Many factors undoubtedly contribute to knowledge diffusion. For instance, growth in electronic and related networking should contribute to diffusion (NumNWPBoost) in spite of the fact that empirical basis for estimating that contribution is very scant. This factor is dependent in IFs on the extent of networking or the "number of networked persons" in a society (NUMNWP), relative to the potential level of networking; when the full potential is achieved, the full incremental impact of networking (numnwpgrinc) passes through to multifactor productivity growth.

2. Human capital quality. This term has two components, one from changes (CngEduc) in educational spending (GDS) and the other from changes in health expenditure (CngHlth), both relative to GDP. Barro and Sala-i-Martin (1999: 433) estimate that a 1.5% increase in government expenditures on education translates into approximately a 0.3% increase in annual economic growth (elmfped).

3. Social capital quality. There is also an addition to growth (EconFreeGF) that can come from change in the level of economic freedom (ECONFREE); the value of the parameter (elgref) was estimated in a cross-sectional relationship of change in GDP level from 1985 to 1995 with the level of economic freedom. Barro places great emphasis in his estimation work on the "rule of law" and it may be desirable to substitute such a concept in the future.

4. Physical capital quality. Robert Ayres has correctly emphasized the close relationship between energy supply availability and economic growth. For instance, a rapid increase in world energy prices (WEP) essentially makes much capital stock less valuable. IFs uses world energy price relative to world energy prices in the previous year to compute an energy price term (EnPriceTerm).

The user can in scenarios add a further exogenous factor, by region (MFPADD). Finally, a correction factor (MFPCor) adjusts the entire growth mechanism to initial empirical rates. That adjustment is phased out over time. The computation of the scaling parameter (CDA) assures that gross production is consistent with data the first year.

All of the adjustment terms (for R&D expenditures, human capital quality, and so on) are computed on an additive basis–that is, they are computed as adjustments to underlying patterns and can be added to compute the overall productivity growth rate. They are all applied to the potential value added (VADDP) in each sector. Of course, GDP is the sum across sectors of valued added. Although the production function can serve all sectors of IFs, the parameters agon and enon act as switches; when their values are one, production in the agricultural and primary energy sectors, respectively, are determined in the larger, partial equilibrium submodels and the values then override this computation.

$$VADDP_{r,s} = CDA_{r,s} * TEF_{r,s} * CAPUT_{r,s} *$$
$$KS_{r,s}^{\boldsymbol{CDALFS_{r,s}}} * LABS_{r,s}^{(1-CDALFS_{r,s})}$$
$$s = 3, 4...nsectr \text{ or } s = 1,2...nsectr$$

where

$$CDA_{r,s} = \frac{VADDP^{t=1}_{r,s}}{\left(\boldsymbol{KS}^{t=1}_{r,s}\right)^{\boldsymbol{CDALFS}_{r,s}} * \left(\boldsymbol{LABS}^{t=1}_{r,s}\right)^{\left(1-\boldsymbol{CDALFS_{r,s}}\right)}}$$
$$TEF_{r,s} = TEF^{t-1}_{r,s} * \left(1 + MFPGRO_{r,s}\right)$$

Moving to the computation of the annual growth in multifactor productivity, we turn to the collection of terms that drive it. As discussed above, there is a base rate linked to systemic technology advance and convergence plus four terms that affect its growth over time. In addition, there is a parameter for users to intervene for any country/region (mfpadd).

$$MFPGRO_{r,s} = MFPRATE_{r,s}$$
$$+ KnowledgeTerm_{r,s} + HumanCapitalTerm_{r,s} + SocialCapitalTerm_{r,s} + PhsyicalCapitalTerm_{r,s}$$
$$+ \boldsymbol{mfpadd}_{r}$$

The base rate includes the rate of advance in the leader (mfpleadr), the premium computed for convergence of each country/region (MFPPrem), and a correction term computed in the first year and the then dropping out over time (MFPCor).

$$MFPPrem_r = Func\left(GDPPC_r\right)$$
$$MFPCor^{\boldsymbol{t=1}}_{r,s} = MFPGRO^{t=1}_{r,s} - \boldsymbol{MFPRATE}^{t=1}_{r,s}$$
$$MFPCor^{\boldsymbol{t}}_{r,s} = ConvergeOverTime(MFPCor^{\boldsymbol{t=1}}_{r,s}, 0, \boldsymbol{mfpconv})$$
$$MFPRATE_{r,s} = \boldsymbol{mfpleadr}_s + MFPPrem_r + MFPCor_{r,s}$$

Finally, we have the four clusters of drivers discussed above, beginning with the knowledge term.

Driver Cluster 1: Knowledge Accumulation and Diffusion

$$KnowledgeTerm_{r,s} = NUMNWPBOOST_r + CNGRandD^{t-1}_r$$
$$NUMNWPBOOST_r = \boldsymbol{numnwpgrinc}_{\boldsymbol{s}} * \frac{NUMNWP_r}{POP_r * \boldsymbol{numnwplim}}$$
$$CNGRandD^{t-1}_r = \left(\frac{GDS^{t-1}_{r,s=RandD}}{GDP^{t-1}_r} - \frac{GDS^{t=1}_{r,s=RandD}}{GDP^{t=1}_r}\right) * \boldsymbol{elmfprd}$$

Driver Cluster 2: Human Capital

$$HumanCapitalTerm_{r,s} = CngEduc_r^{t-1} + CngHlth_r^{t-1}$$

$$CngEduc_r^{t-1} = \left(\frac{GDS_{r,s=EDUC}^{t-1}}{GDP_r^{t-1}} - \frac{GDS_{r,s=EDUC}^{t-1}}{GDP_r^{t-1}} \right) * \boldsymbol{elmfped}$$

$$CngHlth_r^{t-1} = \left(\frac{GDS_{r,s=Health}^{t-1}}{GDP_r^{t-1}} - \frac{GDS_{r,s=Health}^{t=1}}{GDP_r^{t=1}} \right) * \boldsymbol{elmfphl}$$

Driver Cluster 3: Social Capital

$$SocialCapitalTerm_{r,s} = EconFreeGF_r$$

$$EconFreeGF_r = (ECONFREE_r - ECONFREE_r^{t-1}) * \boldsymbol{elgref}$$

Driver Cluster 4: Physical Capital

$$PhysicalCapitalTerm_{r,s} = EnPriceTerm^{t-1}$$

$$EnPriceTerm^{t-1} = (\frac{WEP^{t-1} - WEP^{t=1}}{WEP^{t=1}}) * \boldsymbol{elmfpep}$$

IFs normally does not use the above equations for the first two sectors because the agriculture and energy models provide gross production for them (unless those sectors are disconnected from economics using the agon and/or enon parameters).

Physical shortages may constrain actual value added in each sector (VADD) relative to potential production. Specifically, IFs assumes that energy shortages (ENSHO), as a portion of domestic energy demand (ENDEM) and export commitments (ENX) lower actual production through a physical shortage multiplier factor (SHOMF). A parameter/switch (squeeze) controls this linkage and can turn it off.

$$VADD_{r,s} = VADDP_{r,s} * (1 - ShoMF_r) * \left(\frac{MKAV_{s\ =\ manuf}}{\boldsymbol{MKAV}_{\mathrm{s=manuf}}^{\mathrm{t=1}}} \right)^{\boldsymbol{prodme}}$$

where

$$ShoMF = \frac{ENSHO_r}{ENDEM_r + ENX_r} * \boldsymbol{squeez}$$

In addition, the translation of potential into actual production depends on the imports of manufactured goods (MKAV), which serve as a proxy for both availability of intermediate goods and for technological imports. A parameter (PRODME) also controls this relationship.

3.2 Gross Production and Intersectoral Flows

Having obtained value added in each sector it is possible using an exogenously provided input/output matrix (A) to determine the level of gross production in each sector. We should note, however, that the A-matrix is actually computed as a function of GDP per capita - the model interpolates among multiple A-matices for various levels of GDP per capita in a procedure developed for the GLOBUS model (Hughes 1987).

$$ZS_{r,s} = \frac{VADD_{r,s}}{1 - \sum^{Row} \boldsymbol{A}_{\text{row,column=s}}}$$

Given gross production and the A-matrix we can compute intersectoral flows (INTS).

$$INTS_{row,column=s} = ZS_{r,s} * \boldsymbol{A}_{\text{row, column=s}}$$

Production available for final demand (PFD) is the residual of gross production minus the sum delivered to all columns.

$$PFD_{r,s} = ZS_{r,s} - \sum^{Column} INTS_{row=s,column}$$

For the multiple A-matrices, which are created in the pre-processor of IFs, the project it turned to the IO matrices collected in the Global Trade Analysis Project, specifically Version 5 of the GTAP database. That database includes extensive data, including IO matrices, for 66 regions/individual countries across 57 sectors. With origins of the now global project at the agricultural economics department of Purdue, GTAP heavily represents agricultural sectors.

Dimaranan and McDougall (2002) and contributors documented the most recent GTAP data. The project, begun only in 1992, has already produced its fifth version of data and can count 1200 global researchers as part of the GTAP consortium. Although the GTAP data by no means provide everything that was needed for the generation of universal SAMs, the project is aware of the utility of SAMs (Brockmeier and Arndt 2002) and provided two primary data inputs.

The processing of the IO matrices from GTAP involved several steps. First, the existing matrices from GTAP were collapsed into the six sectors of IFs using a concordance table mapping the 57 GTAP sectors into the six IFs sectors.

Second, a set of nine generic IO matrices were generated to represent the average technical coefficient pattern of countries at different levels of GDP per capita. The generic matrices were calculated as unweighted averages of matrices for all countries with GDPs per capita in categories established by lower-end breakpoints of $0, $175, $375, $750, $1,500, $3,000, $6,000, $12,000, and $24,000. The assumption is that countries at different GDP per capita levels typically use different types of technology. The resultant IO matrices bear this out in ways that seem intuitively plausible. Tables 3.1 and 3.2 show the technical coefficient matrices for extreme levels of GDP/capita, below $100 and above $24,000, respectively. Note, for instance, how much lower a share of manufactures goes into the agricultural sector in the richest countries relative to the poorest, and how much more of the IC sector goes back into the IC sector in richer countries.

	AG	RM	PE	MN	SR	IC
AG Sector	0.2624	0.0112	0.0008	0.0846	0.0194	0.0014

RM Sector	0.0041	0.0425	0.1571	0.0499	0.0087	0.0418
PE Sector	0.0048	0.2158	0.0265	0.0735	0.0119	0.0362
MN Sector	0.0522	0.0540	0.0687	0.1652	0.0774	0.0780
SR Sector	0.1847	0.2260	0.2177	0.1797	0.1721	0.1808
IC Sector	0.0026	0.0090	0.0040	0.0058	0.0105	0.0271

Table 3.1 Generic IO Matrix for Countries with GDP/Capita Below $100

	AG	RM	PE	MN	SR	IC
AG Sector	0.3483	0.0005	0.0017	0.0133	0.0107	0.0004
RM Sector	0.0132	0.0366	0.1385	0.0186	0.0063	0.0067
PE Sector	0.0141	0.2660	0.0118	0.0823	0.0040	0.0287
MN Sector	0.0645	0.0614	0.0822	0.1812	0.0670	0.0856
SR Sector	0.1586	0.1786	0.1533	0.2004	0.2399	0.1632
IC Sector	0.0061	0.0093	0.0113	0.0156	0.0169	0.0966

Table 3.2 Generic IO Matrix for Countries with GDP/Capita Above $24,000

Third, these generic matrices are used for two purposes. First, they are used for estimating values for countries of IFs that are NOT in the GTAP data set. Second, they are used in the actual dynamic calculations of the model. As countries rise in GDP/capita, interpolations between matrices above and below their level allow us to gradually change the matrix representing each country.

GTAP also provides data on return to four factors of production in each sector: land, unskilled labor, skilled labor, and capital. These returns represent value added and are very important data for the value added blocks of the SAM. The pre-processor also collapses these values into the six sectors of IFs and computes generic shares of the factors in value added by GDP per capita category, using the same unweighted average technique used for the IO coefficients. Once again the generic value-added shares are used both to fill country holes in the GTAP data set and to provide a basis for dynamically representing changes in those shares as countries develop.

	AG	RM	PE	MN	SR	IC
Unskilled	0.2873	0.1544	0.1763	0.1378	0.2878	0.1721
Skilled	0.0063	0.0264	0.0384	0.0234	0.1325	0.1132

Table 3.3 Generic Returns to Labor for Countries Below GDP/Capita $100

	AG	RM	PE	MN	SR	IC
Unskilled	0.1795	0.2146	0.0854	0.2159	0.2074	0.2054
Skilled	0.0386	0.0842	0.0952	0.1060	0.1715	0.1618

Table 3.4 Generic Returns to Labor for Countries Above GDP/Capita $24,000

The changes across the levels of GDP/capita appear reasonable. Note, for instance, the general shift of return to skilled from unskilled labor and the increase in returns to labor in total for the manufacturing and ICT sectors (at the expense of capital and other inputs).

The equations for value added and income in household categories will be presented later, in the discussion of households as agents.

3.3 Labor Supply and Capital-Labor Shares of Production

The inputs to the production function are for the most part documented elsewhere in this document or IFs Help system, with two exceptions: labor supply by sector and the Cobb-Douglas coefficients (the respective shares of capital and labor in total value added).

Labor supply (LAB) is a function of population, depending on an exogenously provided labor force participation rate (lapopr). Although the empirical basis for this parameter initially requires that we apply it to the total population, it is important that we change the size of the labor force only as the population in primary years of working age (15 to 65), generated in the population model, changes.

$$LAB_r = \frac{POP15to65_r^t}{POP15to65_r^{t=1}} * POP_r^{t=1} * lapopr_r$$

Labor by sector of the economy (LABS) is a share of the total labor force (LAB) minus unemployment calculated at an exogenous unemployment rate (UNEMPR). The sectoral share is calculated in a function that estimates the labor demand for each unit of value added (VADD) at given levels of GDP per capita (GDPPC).

$$LABS_{r,s} = \frac{LAB_r * (1 - \boldsymbol{unempr_r}) * \sum^{H} LaborF_{r,s}}{\sum^{S}\sum^{H} LaborF_{r,s}}$$

where

$$LaborF_{r,s} = AnalFunc(GDPPC_r, VADD_{r,s})$$

The Cobb-Douglas exponent (CDALF) of the production function is known to change over long time periods, giving somewhat less weight to capital as an economy becomes more capital intensive (see, for instance, Thirlwall 1977: chapter 2). The GTAP project data again provided the basis for an estimation of this relationship, shown in Figure 3.2

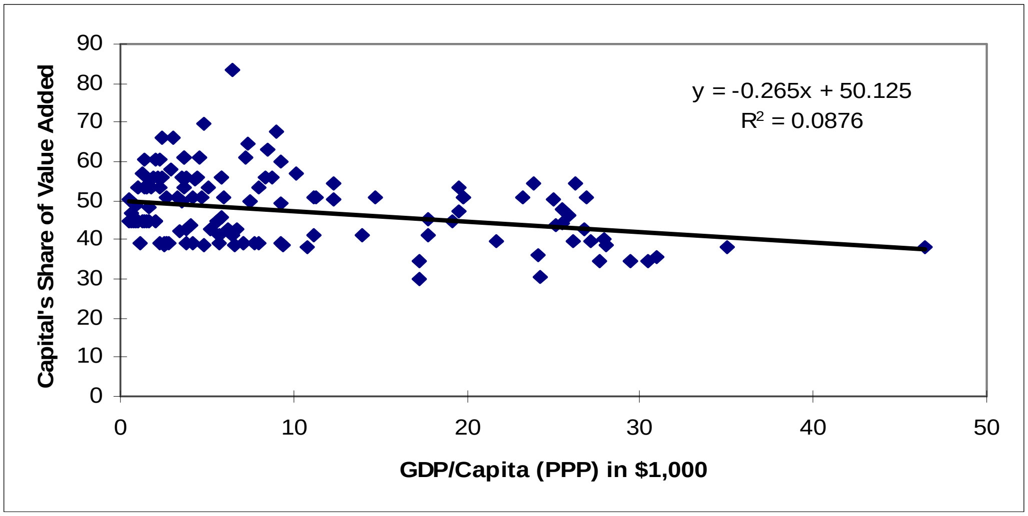


Figure 3.2. Capital Share (Alpha) as a Function of GDP per Capita

That function, in combination with data from Thirlwall and others on sectoral differences in capital share, allow the computation of sectoral capital shares (CDAlfS), normalized so as to generate CDALF for the total economy. A parameter (salpha) represents a generic pattern of capital share variation across production sectors.

$$CDALF_r = AnalFunc(GDPPCP_r)$$

$$CDAlfS_{r,s} = Normalization(CDALF_r, \mathbf{salpha}_s)$$

3.4 GDP at Exchange Rates and Purchasing Power Parity

Gross regional or domestic product (GDP) is the sum of value added across sectors, which would also equal the sum of production for final demand across sectors.

$$GDP_r = \sum^{S} VADD_{r,s}$$

The GDP per capita (GDPPC) and the regional economic growth rate (GDPR) follow easily.

$$GDPPC_r = \frac{GDP_r}{POP_r}$$

$$GDPR_r = \frac{GDP_r - GDP_r^{t-1}}{GDP_r^{t-1}}$$

The basic GDP figures for the model are represented in dollars at official exchange rate values. It is important, however, to estimate the value of GDP and GDPPC at purchasing power parity levels as well (GDPP and GDPPCP). To do that we need to compute a purchasing power parity conversion value (PPPConV). Data sources provide the initial conversion value. IFs uses an analytic function based on GDP per capita to compute change in the conversion value over time.

$$GDPP_r = GDP_r * PPPConV_r$$
$$GDPPCP_r = GDPPC_r * PPPConV_r$$
where
$$PPPConV_r = PPConV_r^{t=1} * \frac{AnalFunc(GDPPC_r)}{AnalFunc(GDPPC_r^{t=1})}$$

3.5 Demand and Expenditure Components Other Than Trade

As the agent-class structure of IFs expands, the formulations for behaviour of government, firms, and households, all of which are discussed in the next several chapters, gradually come to replace more aggregated relationships. Although it is unlikely, for instance, the production function could theoretically become part of the structure of behaviour of firms.

With respect to the demand or expenditure component side of the goods and services market module, it already proves, in fact, better to discuss those in the next two chapters than to do so here. Chapter 4 will discuss the formulation for total government consumption (GOVCON) and Chapter 5 will discuss those for household consumption, C, and investment (I).

Expenditure components can have sectoral detail of two kinds. The first is sector of origin, for instance, the portion of investment that comes from the manufacturing sector (INVS) or the portion of governmental consumption that comes from the service sector (GS). The second is the sector of destination, relevant to the sector that receives investment (IDS) and the target areas such as health of government spending (GDS). Household consumption (CS) is by sector of origin. Again, Chapters 4 and 5 discuss the forecasting of each of these sectoral break-downs by origin. And it is calculation by the sector of origin that determines the demand upon the goods and services market and that will be used later in this chapter in the discussion of inventory stocks and prices.

With respect to the destination of expenditure components, see the description of the policy model, in the Help system, for government expenditures by sector of destination. A later section in this chapter will present investment by destination because it, like prices, is one of the mechanisms for market equilibration (see again Figure 4.1).

3.6 Trade

Imports and exports respond to regional prices (PRI) relative to those elsewhere. As a measure of prices elsewhere, IFs uses a world average price (WP), weighted by regional gross production and adjusted by the exchange rate (EXRATE).

$$WP_s = \frac{\sum^{R} (PRI_{r,s}^{t-1} * EXRATE_r * ZS_{r,s})}{\sum^{R} ZS_{r,s}}$$

The computation uses lagged prices because at this point the recursive equation system has not yet computed current prices.

Exports are responsive to both changes in production and changes in prices via respective elasticities. On the production side we begin by computing an export base (XBASE). It is initial exports (XS) plus some portion (XKAV) of growth in production, represented by potential gross sectoral production (ZSP). Representing a moving average of incremental production that is exported helps maintain global balance and stable behavior in long-term forecasting. The exported portion is modified over time in response to two elasticities. The first is a fairly standard elasticity of exports with income/production growth (elasxinc). The second is an export shift parameter that one would normally use to represent scenarios about export promotion or constraint.

$$XBASE_{r,s} = XS_{r,s}^{t=1} + (ZSP_{r,s} - ZSP_{r,s}^{t=1}) * XKAV_{r,s} * \boldsymbol{elasxinc}_r * (1 + \boldsymbol{xshift}_r)$$

Given the export base, export capacity (XC) responds to the difference between local and global prices using an elasticity of trade with prices (elastrpr). In addition we use two parameters (first order and second order) to pursue dynamically a global trade balance over time (elprx1 and elprx2). You may wish more detail on the adjustment mechanism.

$$XC_{r,s} = XBASE_{r,s}$$

$$* \left(1 + \left(\frac{PRI_{r,s}^{t-1} * EXRATE_r - WP_s}{WP_s} * \boldsymbol{elastrpr}_s\right)\right)^{\boldsymbol{elprx1}}$$

$$* \left(1 + \left(\frac{PRI_{r,s}^{t-1} * EXRATE_r - WP_s}{WP_s} - \frac{PRI_{r,s}^{t-2} * EXRATE_r^{t-1} - WP_r^{t-1}}{WP_r^{t-1}} * \boldsymbol{elastrpr}_s\right)\right)^{\boldsymbol{elprx2}}$$

Import capacities or demands (MD) are almost exactly analogous. Whereas exports are tied to production, however, imports are tied to a demand base (DBASE) made up of final demands plus intersectoral flows (INTS).

$$DBASE_{r,s} = CS_{r,s} + GS_{r,s} + INVS_{r,s} + INTS_{r,s}$$

Imports are responsive to both changes in income and changes in prices and respective elasticities. We use the demand base as the basis for the income term. Specifically, we create a basic import level (MBASE) that grows with the demand base, responsive to an income elasticity parameter for imports (elasminc).

$$MBASE_{r,s} = MS_{r,s}^{t=1} + (DBASE_{r,s} - DBASE_{r,s}^{t=1}) * MKAV_{r,s} * \boldsymbol{elasminc}_r$$

A moving average for imports (MKAV) as a portion of changes in the demand base helps maintain global balance and stable behavior over the long-term.

Given this income responsive import base, regional prices relative to global ones (again with first and second order terms), an elasticity of imports with prices (elastrpr), and parameters for dynamic change of imports (elprm1 and elprm2) largely determine import demands. One last factor, however, is a domestic protection multiplier (protecm), which can cause the import price (MPRIC) to rise or fall relative to the world price.

$$MD_{r,s} = MBASE_{r,s} * \left(1 + \left(\frac{PRI_{r,s}^{t-1} * EXRATE_r - MPRIC_{r,s}}{MPRIC_{r,s}} * \boldsymbol{elastrpr_s}\right)\right)^{\boldsymbol{elprm1}}$$

$$* \left(1 + \left(\frac{PRI_{r,s}^{t-1} * EXRATE_r - MPRIC_{r,s}}{MPRIC_{r,s}} - \frac{PRI_{r,s}^{t-2} * EXRATE_r^{t-1} - MPRIC_{r,s}^{t-1}}{MPRIC_{r,s}^{t-1}} * \boldsymbol{elastrpr_s}\right)\right)^{\boldsymbol{elprm2}}$$

where

$$MPRIC_{r,s} = WP_s * \boldsymbol{protecm}_r$$

World export capacity (WXC) and world import demand (WMD) are simply sums across regions.

$$WXC_s = \sum^{R} XC_{r,s}$$

$$WMD_s = \sum^{R} MD_{r,s}$$

These will always be somewhat different. Actual world trade (WT) is the average of the two.

$$WT_s = \frac{WXC_s + WMD_s}{2}$$

We are now able to compute actual sectoral exports (XS) and imports (MS), normalizing the capacity for exports and the demand for imports to the actual world trade.

$$XS_{r,s} = WT_s * \frac{XC_{r,s}}{WXC_s}$$

$$MS_{r,s} = WT_s * \frac{MD_{r,s}}{WMD_s}$$

The above equations are necessary only for three of the five economic sectors. The agriculture and energy models compute trade in those sectors separately.

We can now update the moving average export (XKAV) and import (MKAV) propensities for the next cycle. This requires historic weights for exports (XHW) and imports (MHW).

$$XKAV_{r,s}^{t+1} = XKAV_{r,s} * \boldsymbol{xhw} + (1 - \boldsymbol{xhw}) * \frac{XS_{r,s}}{ZSP_{r,s}}$$

$$MKAV_{r,s}^{t+1} = MKAV_{r,s} * \boldsymbol{mhw} + (1 - \boldsymbol{mwh}) * \frac{MS_{r,s}}{DBASE_{r,s}}$$

Given the computation of sectoral exports and imports for all sectors (in this or other models), it is possible to compute total exports (X) and imports (M).

$$X_r = \sum^{S} XS_{r,s}$$

$$M_r = \sum_{s}^{S} MS_{r,s}$$

IFs also computes these in a "relative-priced adjusted" form, multiplying the real sectoral values by global prices. Why is this important? If, for example, a country were highly dependent on energy exports and the price of energy (from the energy submodel) doubled relative to other prices, failure to adjust trade for prices would understand the country's trade balance. It is the relative price-adjusted trade that is taken to the international financial calculations (see Chapter 6).

$$XRPA_r = \sum_{r}^{S} XS_{r,s} * WP_s$$

$$MRPA_r = \sum^{S} MS_{r,s} * WP_s$$

A purely optional adjustment to import and export levels is available for the model user who wishes to examine the hypothetical impact of changes in the terms of trade. The terms of trade parameter (TERMX) is a multiplier with a normal value of 1.0. Higher values shift the terms of trade in the favor of Southern or less-developed regions (those with initial GDP per capita less than $5,000) and lower values favor Northern regions. The determination of North and South by initial GDP per capita and the fixing of those categories is important. Too many who argue that the gap has been increasing over time regularly recategorize countries.

if $\mathrm{GDPPC}_r^{t=1} > \$5{,}000$ then

$$X_r = X_r / \boldsymbol{termx}$$

if $\mathrm{GDPPC}_r^{t=1} <= \$5{,}000$ then

$$X_r = X_r * \boldsymbol{termx}$$

$$\mathrm{M}_r = M_r / \boldsymbol{termx}$$

The adjustment to regional exports and imports for hypothetical terms-of-trade change can result in a failure of exports and imports to sum across regions to the same global total. At this point IFs thus normalizes regional exports and imports to a total value for world trade equal to the average of the current sums of exports and imports across regions.

Given final values for regional exports and imports it is possible to compute regional trade balances (TRADEBAL), using relative-price adjusted exports and imports.

$$TRADEBAL_r = XRPA_r - MRPA_r$$

3.7 Stocks and Prices

IFs is fundamentally a general equilibrium model (GEM), but one in which inventory stocks serve as a temporary buffer between demand and supply and prices act to move the system towards equilibrium over time. The production available for final demand (PFD) and imports (MS) serve to increase stocks. Consumption (CS), investment (INVS), and government spending (GS) by sector of origin serve to decrease stocks, as do exports (XS).

$$ST_{r,s} = ST_{r,s}^{t-1} + PFD_{r,s} - CS_{r,s} - INVS_{r,s}$$
$$- GS_{r,s} - XS_{r,s} + MS_{r,s}$$

Prices (PRI) in IFs are quite important in the agricultural and energy models where they directly affect demand and supply through elasticities. In the economic model they have lesser impact, primarily through trade and secondarily through price-responsiveness of sectoral consumption. In addition, prices implicitly affect investment by destination, although for computational sequence reasons IFs actually uses stock levels directly to redirect investment by sector. Prices in IFs are relative prices and are indices around initial base values of "1." They are based on stock levels and a second order stock change term.

$$PRI_{r,s} = PRI_{r,s}^{t-1} * \left(1 + \frac{ST_{r,s} - \mathbf{dstl} * STBASE_{r,s}}{STBASE_{r,s}}\right)^{\mathbf{elprst1}}$$
$$* \left(1 + \frac{ST_{r,s} - ST_{r,s}^{t-1} * GDPR_{r}^{t=1}}{STBASE_{r,s}}\right)^{\mathbf{elprst2}}$$

where

$$STBASE_{r,s} = ZS_{r,s} + MS_{r,s}^{t=1} * \frac{GDPPOT_r}{GDP_r^{t=1}}$$

The stock base (STBASE) is the sum of gross production (important to large producers in an economic sector, whether they consume domestically or export) and initial imports scaled up by potential GDP growth (important to large importers, when domestic production is small). The desired level of stocks as a portion of the base (dstl) is exogenous.

3.8 Investment by Destination

The discussion to this point has now discussed how changes in sectoral prices affect sectoral demand and trade, thereby moving the system towards equilibrium. The introduction noted that changes in the pattern of investment by destination also help maintain equilibrium within sectors (as opposed to equilibrium between aggregate supply and demand). IFs could base changes in investment patterns on changes in relative sectoral prices (or, ideally, to resultant profit levels in a sector). Since prices themselves respond to imbalances in inventory stocks, however, it is equivalent to link investment by destination to those inventory levels.

The determination of investment by destination is a two-step procedure. First, IFs computes demand for investment by each sector (IFSDEM), responsive primarily to inventory levels. The base value of investment demand is dependent on the total level of gross capital formation (I) and the portion of that directed into a particular sector (IDK) during the last time step. Parameters (ELINST1 and ELINST2) control the speed of adjustment. Second, IFs normalizes those demands to the total level of gross capital formation (the computation of which is discussed in Chapter 6).

$$IFSDEM_{r,s} = IDK_{r,s}^{t-1} * I_r * \left(1 + \frac{ST_{r,s} - \mathbf{dstl} * STBASE_{r,s}}{STBASE_{r,s}}\right)^{\mathbf{elinst1}} * \left(1 + \frac{ST_{r,s} - ST_{r,s}^{t-1}}{STBASE_{r,s}}\right)^{\mathbf{elinst2}}$$

where

$$STBASE_{r,s} = ZS_{r,s} + MS_{r,s}^{t=1} * \frac{GDPPOT_r}{GDP_r^{t=1}}$$

The above equation handles the sectors other than agriculture and energy. The model for agriculture provides investment need for that sector (IANEED), as does the energy model (IENEED).

$$IDSDEM_{r,s=1} = IANEED_r$$

$$IDSDEM_{r,s=2} = IENEED_r$$

To obtain actual investment by destination (IDS) we can distribute total investment (I) across sectors proportionately to their demands.

$$IDS_{r,s} = I_r * \frac{IDSDEM_{r,s}}{\sum^{S} IDSDEM_{r,s}}$$

As an indicator (and as the basis for sectoral investment splits in the next time cycle) we can compute the fractions going to each sector (IDK).

$$IDK_{r,s} = \frac{IDS_{r,s}}{I_r}$$

Capital stock (KS) in the next time period is simply the old capital stock plus investment by destination, minus depreciation (the capital stock divided by its lifetime, lks), and minus the portion of capital destroyed as civilian damage (CIVDM) in war (see the policy model). The last term is, of course, normally zero.

$$KS_{r,s}^{t+1} = KS_{r,s} + IDS_{r,s} - \frac{KS_{r,s}}{\mathbf{lks}} - KS_{r,s} * CIVDM_r$$

IFs makes no effort to represent a gestation period for capital of more than 1 year. Although it would be desirable to do so, it would also require a "look ahead" capability of the model to plan capital requirements several years in the future. Such a feature would add some realistic cyclical behavior to the model, but would also be somewhat difficult to control. And again, it is not the aim of IFs to capture business cycles.

3.9 Indicators

The economic model computes several indicators of interest to many IFs users. These include global product (WGDP), global product per capita (WGDPPC), the percent of global production in each economic sector (WPROD), an absolute measure of the per capita GDP gap between more developed (D) and less economically developed (L) regions (NSGAPA), a relative measure of the same gap (NSGAPR), and the less developed world’s share of global manufacturing production (SMAN).

$$WGDP = \sum^{R} GDP_r$$

$$WGDPPC = \frac{WGDP}{WPOP}$$

$$WPROD_s = \frac{\sum^{R} ZS_{r,s}}{\sum^{R} \sum^{S} ZS_{r,s}}$$

$$NSGAPA = \left(\frac{\sum^{D} GDP_r}{\sum^{D} POP_r} \right) - \left(\frac{\sum^{L} GDP_r}{\sum^{L} POP_r} \right)$$

$$NSGAPR = \frac{\left(\frac{\sum^{D} GDP_r}{\sum^{D} POP_r} \right)}{\left(\frac{\sum^{L} GDP_r}{\sum^{L} POP_r} \right)}$$

$$SMAN = \frac{\sum_{r,s}^{L} ZS_{r,s}}{\sum^{R} ZS_{r,s}} * 100$$

4. Government

Households and firms clearly are agent classes whose collective behavior merits representation and to which the next chapter will turn. Yet households and firms are large classes of actors and their behavior is therefore less particularistic than that of governments. Moreover, when we think about policy intervention, it is to governments that we often first look. Thus moving on from the commodities or sectors row and column in SAM matrices, it makes sense to begin governments. Insofar as data allow, the IFs treatment of government is consolidated government; in reality many data are available only for central government.

This chapter begins with revenue raising behavior, moves next to expenditures, and concludes by looking at the equilibrating mechanisms that link the two. The chapter will position us to move on to consideration of the private sector, households and firms, in the next chapter.

4.1 Revenues

Background Data and Initialization

Before turning to the formulations used for forecasting in the model, it is useful to see some of the data that are used in support of those formulations and also for filling holes with the pre-processor in the initialization stage.

Figure 4.1 shows the tendency for revenues as a percentage of GDP to grow quite substantially with GDP/capita. .

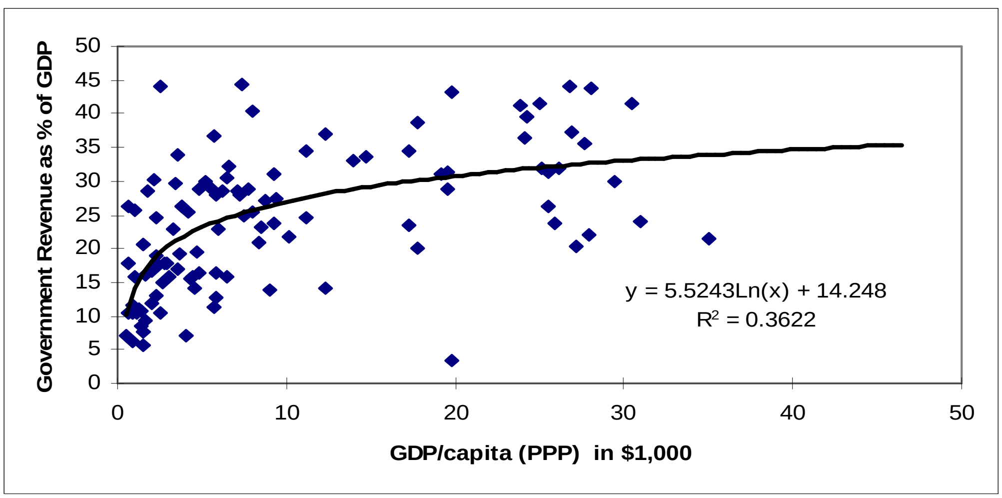


Figure 4.1. Government Revenue Share as Function of GDP/capita (PPP)

The pre-processor then turns to the specific sources of that revenue, simplifying it into four major streams: indirect taxes, corporate taxes, social security/welfare taxes (from firms and households without rate distinction), and household taxes. Figures 4.2-4.4

show the typical share of indirect, corporate, and social security taxes, respectively in total government revenue. Data on total government revenues as a portion of GDP, on indirect taxes as a portion of government revenue, and Social Security/welfare taxes as a portion of government revenue come from the World Bank's World Development Indicators (2002). Data on corporate taxes come from the Government Finance Statistics Yearbook (1999). It is obvious from Figures 4.2-4.4 that there is not a strong relationship between tax shares and GDP per capita. Fortunately, the data on actual shares is quite extensive, so the functions need fill relatively few holes. Figures 4.2-4.4 do suggest a typical pattern of change in taxation sources as GDP/capita increases, namely some decrease in indirect and corporate tax shares, with an increase in social security/welfare taxes. It will be possible in the future to build that pattern more directly into the forecast formulations shown below.

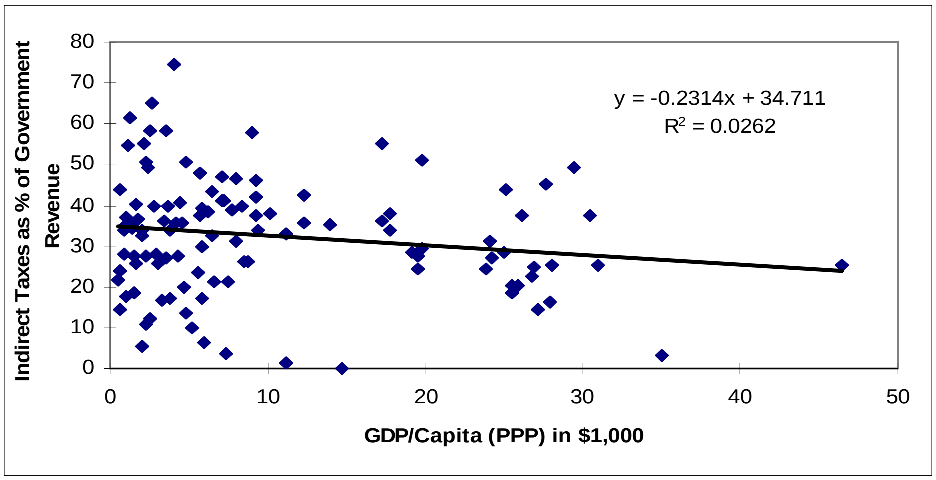


Figure 4.2. Indirect Tax Share of Government Revenue as Function of GDP/capita (PPP)

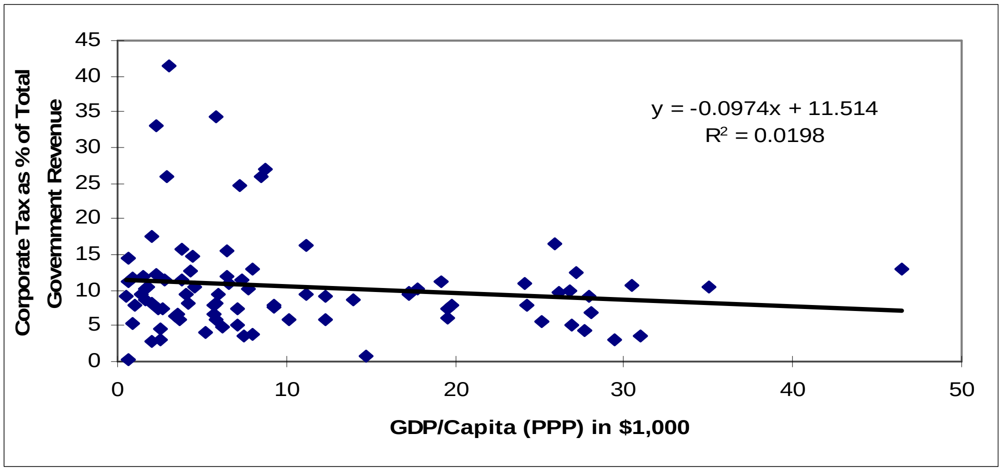


Figure 4.3. Corporate Tax Share of Government Revenue as Function of GDP/capita (PPP)

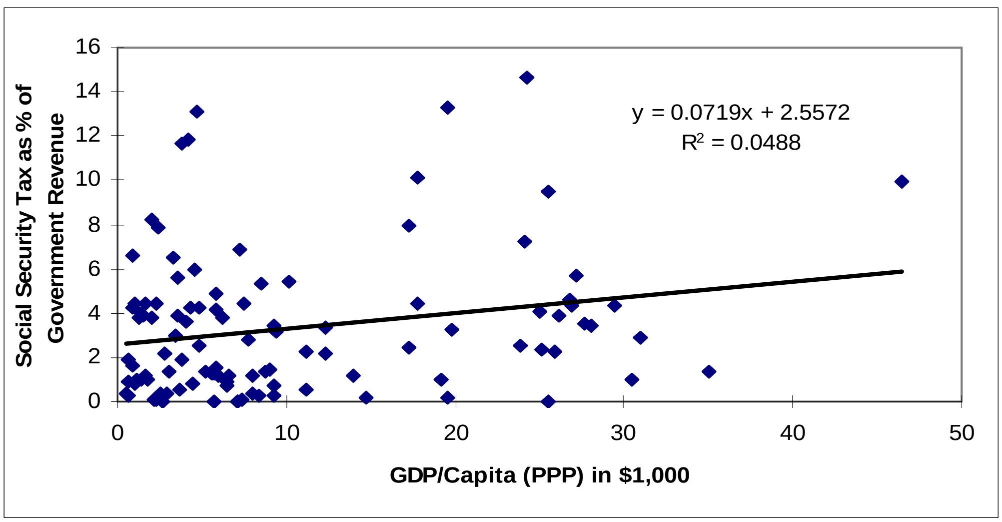


Figure 4.4. Social Security/Welfare Tax Share of Government Revenue as Function of GDP/capita (PPP)

The pre-processor computes the household tax share as the residual after the indirect, corporate/firm and social security tax shares are deducted from 100% of total government revenue. At this stage, identical household tax rates are being assigned to unskilled and skilled households (which implies no progressivity or regressivity in the tax rates computed as a share of income); we are looking for data on relative tax burdens, but absence of differentiation is not a bad initial working assumption.

$$HHTaxShr_{r,h} = 100 - IndirectTaxShr_r - FirmTaxShr_r - SSWelTaxShr_r$$

Given shares of total tax revenue provided by firms and households, as well as collections for social security/welfare, the pre-processor can compute tax rates on income as the tax collections divided by income. The computed rates are those used above in the annual calculations of the model.

$$FIRMTAXR_r = GOVREV_r^{t=1} * FirmTaxShr_r^{t=1} / FirmInc_r^{t=1}$$

$$HHTaxR_{r,h} = GOVREV_r^{t=1} * HHTaxShr_r^{t=1} / HHInc_r^{t=1}$$

$$SSWELTAXR_r = GOVREV_r^{t=1} * SSWelTaxShr_r^{t=1} / (FirmInc_r^{t=1} + HHInc_r^{t=1})$$

Forecasting

The next chapter will detail the calculation of household and firm income, beginning with the calculation of such income before taxes and transfers (HHIncBTT and FirmIncBTT). The model represents five revenue streams from taxes on the those incomes: household income taxes (HHTAX), household social security/welfare taxes (HHGOVSS), firm income taxes (FIRMTAX), firm social security/welfare taxes (FIRMGOVSS), and indirect taxes (INDIRECTTAX). As indicated above, we have no database to distinguish social security/welfare taxes assessed on households and firms. In each revenue equation there are exogenous multipliers that the user can manipulate to simulate changes in revenue streams (hhtaxrm, etc.) and total government revenues (govrevm). [Note govrevm not now always applied.] In addition there is a multiplier on revenues (MulRev) whose calculation we shall see below in the discussion of balancing of revenues and expenditures, and whose application lags one year behind the calculation. Some governments also have net domestic revenues from state-owned enterprises, but the model does not represent this stream (which is, in any case, often actually negative).

$$HHTAX_{r,h} = HHIncBTT_{r,h} * \frac{HHTAXR_{r,h}}{100} * \boldsymbol{hhtaxrm}_{r,h} * \boldsymbol{govrevm}_r * MulRev_r^{t-1}$$

$$HHGOVSS_{r,h} = HHIncBTT_{r,h} * \frac{SSWELTAXR_r}{100} * \boldsymbol{ssweltaxrm}_r * \boldsymbol{govrevm}_r * MulRev_r^{t-1}$$

$$FIRMTAX_r = FirmIncBTT_r * \frac{FIRMTAXR_r}{100} * \boldsymbol{firmtaxrm}_r * MulRev_r^{t-1}$$

$$FIRMGOVSS_r = FirmIncBTT_r * \frac{SSWELTAXR_r}{100} * \boldsymbol{ssweltaxrm}_r * \boldsymbol{govrevm}_r * MulRev_r^{t-1}$$

$$INDIRECTTAX_r = FirmIncBTT_r * \frac{INDIRECTTAXR_r}{100} * \boldsymbol{indirecttaxrm}_r * MulRev_r^{t-1}$$

Total domestic government revenues, before consideration of external revenues in the form of foreign aid (GovRevBA) is computed from the five streams, after summing the social security or welfare taxes across households and firms (SSWELTAX).

$$SSWELTAX_r = \sum^{H} HHGOVSS_{r,h} + FIRMGOVSS_r$$

$$GovRevBA_r = \sum^{H} HHTAX_{r,h} + FIRMTAX_r + SSWELTAX_r + INDIRECTTAX_r$$

It is useful also to compute the overall tax rate as an output indicator.

$$TAXRA_r = GovRevBA_r / GDP_r$$

For aid recipients only, the amount of government receipts adjusts government revenues.

$$\text{if } \mathrm{AID}_r > 0 \text{ then}$$
$$GOVREV_r = GovRevBA_r + AID_r$$

4.2 Expenditures

Background Data and Initialization

Turning to the expenditure side, Figure 4.4 shows the function estimated cross-sectionally in order to fill the relatively few holes in government expenditures as a portion of GDP (again using data from the WDI 2002).

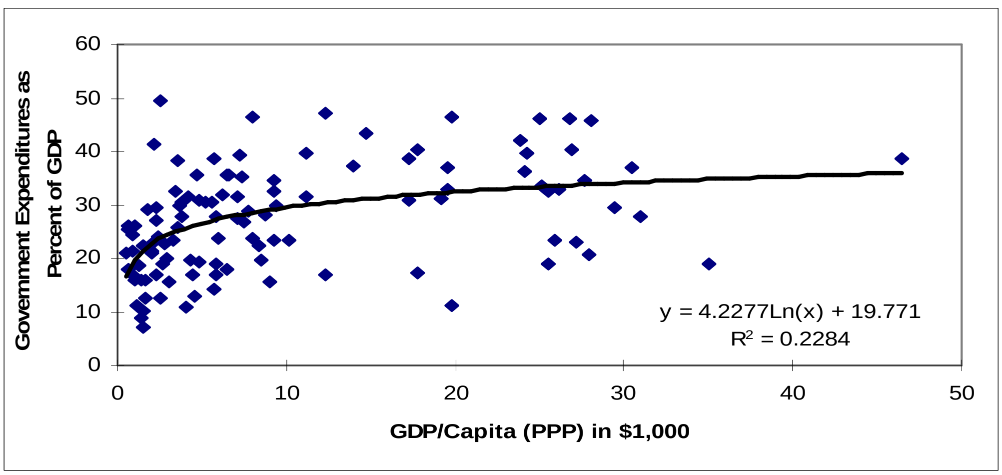


Figure 4.4. Government Expenditure Share as Function of GDP/capita (PPP)

Government expenditures consist of a combination of direct consumption/expenditure and transfer payments. As a general rule, transfer payments grow with GDP per capita more rapidly than does consumption. And within transfer payments, pension payments are growing especially rapidly in many countries, especially more-economically developed ones. Figure 4.5 shows the relationship between GDP/capita and public spending on pensions as a percent of GDP (using data from a World Bank analysis of data drawn from OECD and other sources). This function is used to fill holes in the data set.

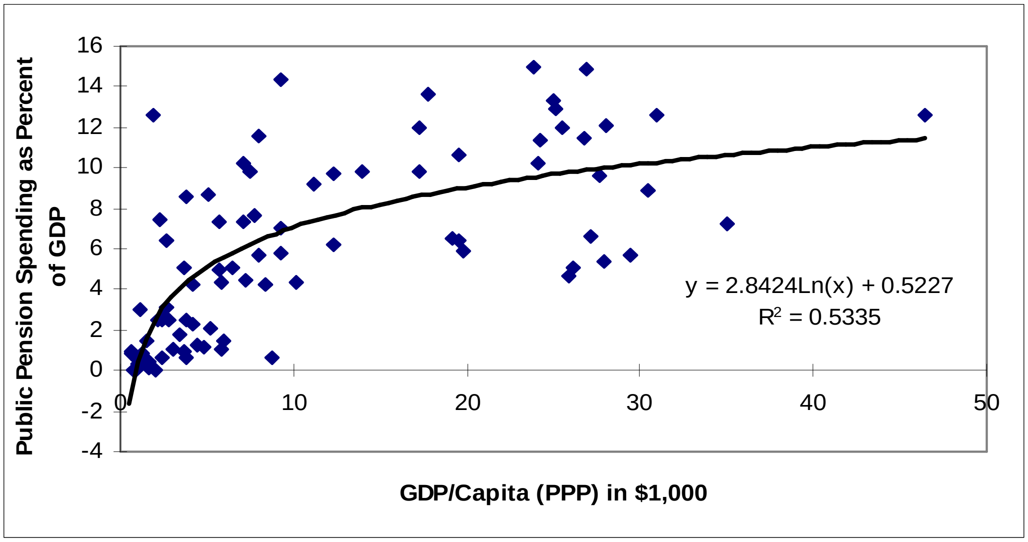


Figure 4.5. Government Spending on Pensions as Function of GDP/capita (PPP)

Because of its importance in and of itself, and as a check on government expenditure data we also look at government consumption data from the WDI 2002 and again fill holes with a function estimated cross-sectionally (see Figure 4.6). Normally, of course, total expenditures of government will exceed consumption because of transfer payments and the pre-processor makes sure that expenditures are at least equal to consumption.

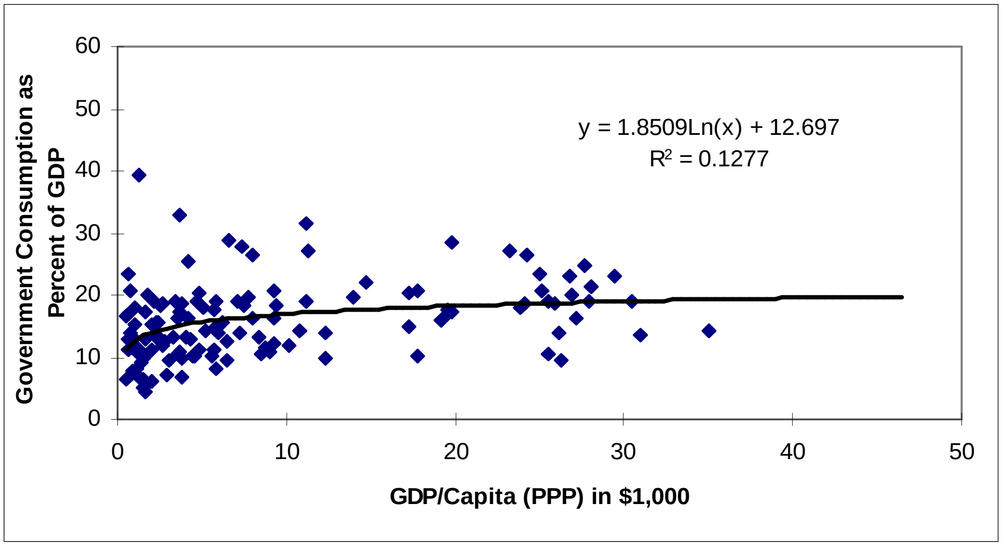


Figure 4.6. Government Consumption Share as Function of GDP/capita (PPP)

The above functions suggest substantial change in governmental expenditure totals and patterns with changing levels of GDP per capita. In the formulations for forecasting o be presented below, it is desirable to represent such change endogenously. The general approach to doing so is based on three assumptions:

- changes in GDP/capita should give rise to changes in expenditure patterns roughly in line with the functions above
- when initial conditions for expenditures by individual countries deviate from the pattern of the lines fit to the data above, those deviations are likely to persist for a considerable time
- the deviations by individual countries from general cross-sectional patterns are likely to erode over time because of budgetary constraints and globalization of patterns

The approach that follows from these assumptions involves computing the ratio of initial conditions for countries to the relationships estimated above and then using those ratios to build in individual country distinctions as GDP/capita changes, but gradually converging country expenditures to the estimated relationships. Before turning to the forecasting formulations, this section indicates the computation of the ratios of initial conditions to estimated values.

Beginning with the ratio for government consumption (GovConR), that is a comparison of actual government consumption (GOVCON) and the value based on the cross-sectionally estimated function. Where there is no initial data for government consumption, the estimated function is used to fill the hole and the ratio will, of course, then be “1”. For most countries, it will vary from that value and indicate the general tendency for a government to "over consume" or "under consume" relative to the cross-sectional function.

$$GovConR_r^{t=1} = \frac{GOVCON_r^{t=1}}{EstGovtConsum_r^{t=1} * GDP_r^{t=1}}$$

$$where$$

$$EstGovtConsum_r^{t=1} = AnalFunc(GDPPCP_r^{t=1})$$

In the initial year, government to household transfers are the residual of government expenditures and consumption.

$$GOVHHTRN_r^{t=1} = GOVEXP_r^{t=1} - GOVCON_r^{t=1}$$

That allows computation of an initial ratio (GovHHTrnR) of actual transfer payments to the estimated one, analogously to the ratio for government consumption that was calculated above. The transfer payment ratio will facilitate forecasting of social security/welfare payments in future years.

$$GovHHTrnR_r^{t=1} = \frac{GOVHHTRN_r^{t=1}}{EstGovHHTrn_r^{t=1} * GOVEXP_r^{t=1}}$$

$$where$$

$$EstGovHHTrn_r^{t=1} = AnalFunc(GDPPCP_r^{t=1})$$

IFs divides transfers into pensions (targeting the elderly) and welfare payments (for needs across the population). Total pension payments (GOVHHPENT) are calculated in the pre-processor, using data when possible and a function estimated cross-sectionally to fill the holes. In the first year IFs bounds that value so that the citizens above 65 years of age are not receiving an average of more than 100% of the GDP per capita. And another ratio (GovHHTrnPenR), this time of total government pensions from data when possible the to pensions estimated from the cross-sectional function, is stored for use in forecasts.

$$GovHHTrnPenR_r^{t=1} = \frac{GOVHHPENT_r^{t=1}}{EstGovtPensions_r^{t=1} * GDP_r^{t=1}}$$

$$where$$

$$EstGovtPensions_r^{t=1} = AnalFunc(GDPPCP_r^{t=1})$$

Given total transfers and total pension payments, the total welfare payments (GOVHHWELTOT) are the residual.

$$GOVHHWELTOT_r^{t=1} = GOVHHTRN_r^{t=1} - GOVHHPENT_r^{t=1}$$

Then IFs splits the pensions and welfare payments across household types according to their relative shares of income.

$$GovHHTTrnPen_{r,h}^{t=1} = GovHHPenT_r^{t=1} * \frac{HHINC_{r,h}^{t=1}}{\sum^{H} HHINC_{r,h}^{t=1}}$$

$$GovHHTTrnWel_{r,h}^{t=1} = GovHHPWelTot_r^{t=1} * \frac{HHINC_{r,h}^{t=1}}{\sum^{H} HHINC_{r,h}^{t=1}}$$

Transfers per capita provide information that will be useful in future years. IFs stores pension transfers relative to the size of the population above 65 years of age and welfare transfers relative to the entire population.

$$GovHHPenPC_r^{t=1} = GovHHPenT_r^{t=1} / POPGT65_r^{t=1}$$

$$GovHHWelPC_r^{t=1} = \sum^{H} GovHHTrnWel_{r,h}^{t=1} / POP_r^{t=1}$$

Forecasting

In future years the total of government expenditures is calculated from the sum of direct consumption and transfers. The two components, however, each require a moderately complex calculation.

$$GOVEXP_r = GOVCON_r + GOVHHTRN_r$$

Consumption. Computation of government consumption (direct expenditures on the military, education, health, R&D, foreign aid, and other categories) begins with use of the function to compute an estimated government consumption (EstGovtConsum) as a portion of GDP, using GDP per capita (PPP) as the driver. The initialization discussion above showed the empirical base of that function. It carries a behavioral assumption of generally increasing expenditures with increases in GDP per capita.

The estimated value then enters a convergence calculation that IFs uses in a number of instances. In the first year a ratio term (GovConR) was computed that represented the degree to which a country's consumption/GDP differed from the estimated value. That ratio multiplies the estimated term in future years, allowing the function normally to increase consumption/GDP as GDP per capita rises. At the same time, such divergence from estimated functions is almost as often a matter of data inadequacy or of temporary factors for a country as it is of persistent idiosyncrasy. The convergence function allows the country/region's value to converge towards the functional calculation over a period of time (govfinconv), usually quite long. Such convergence also helps avoid ceiling effects (e.g. government consumption as 100% of GDP) as GDP per capita rises.

The second term in the equation below is called the Wagner term, after the discoverer of the long-term behavioral tendency for government consumption to rise as a share of GDP, even at stabile levels of GDP per capita. This is built into the consumption calculation through an exogenous parameter (wagnerc) that is multiplied by the number of the forecast year.

$$GOVCON_r = Converge(EstGovtConsum_r * GovConR_r^{t=1}, EstGovtConsum_r, \boldsymbol{govfinconv})$$
$$* WagnerTerm * \boldsymbol{govexpm}_r * MulExp_r^{t-1}$$
$$where$$
$$WagnerTerm = 1 + t * \boldsymbol{wagnerc}$$
$$EstGovtConsum_r = AnalFunc(GDPPCP_r^{t=1})$$

Almost finally, government consumption is further modified by an exogenous multiplier of government expenditures, allowing the user to directly control it by country/region and by an endogenously computed multiplier on expenditures that, parallel to MulRev, reflects the balance or imbalance in government expenditures and the debt level. Finally, and not shown, there is a simple adjustment to reflect the affect that changing levels of foreign assistance receipts can have on consumption.

The division of government expenditures into target destination categories (GDS), part of the broader socio-political module of IFs is described in the Help system of the model. That division is, of course, also a key agent-class behavior. With respect to sector of origin for government consumption (GS), which is information needed for the equilibration mechanism in the core commodities module, IFs simplistically assumes in the pre-processor that all government spending except arms, which has its source in manufactures, comes from services. On a year to year basis, the sectors of origin remained fixed at the initial proportions.

$$GS_{r,s}^{t} = GOVCON_r^{t} * \frac{GS_{r,s}^{t=1}}{GOVCON_r^{t=1}}$$

Transfers. Government transfers, as distinguished from direct consumption expenditures, are computed using two different behavioral logics, a top-down one like the one for government consumption, and a bottom-up logic. The bottom-up logic is especially important in the analysis of pensions, because it is responsive to the changing size of the elderly population.

The top-down logic again uses an aggregate function responsive to changes in GDP per capita.

$$GovHHTrnTop_r = Converge(EstGovtHHTrn_r * GovHHTrnR_r^{t=1}, EstGovtHHTrn_r, \boldsymbol{govfinconv})$$
$$* WagnerTerm * \boldsymbol{govexpm}_r * MulExp_r^{t-1}$$
$$where$$
$$WagnerTerm = 1 + t * \boldsymbol{wagnerc}$$
$$EstGovtHHTrn_{r\,r} = AnalFunc(GDPPCP_r^{t=1})$$

The top-down logic also computes an estimate of pension expenditures using a function estimated cross-sectionally, multiplying that by the ratio of empirical/estimated values computed in the first year.

$$GovHHTrnPenTop_r = EstGovHHTrnPen_r * GovHHTrnPenR_r^{t=1} * MulExp_r^{t-1}$$
$$where$$
$$EstGovHHTrnPen_r = AnalFunc(GDPPCP_r^{t=1})$$

The bottom-up logic looks at the number of people above age 65, and multiplies that number by per capita pension benefits in the first year, adjusted for the increase in GDP per capita. Ideally, this calculation should be adjusted for changing retirement ages, which are becoming younger and thereby further increasing pressure for pensions.

$$GovHHTrnPenBottom_r = PopGT65_r * GovHHPenPC_r^{t=1} * \frac{GDPPC_r^t}{GDPPC_r^{t=1}} * MulExp_r^{t-1}$$

The larger of the two numbers indicates the total pressure in the system for public pensions.

$$GovHHTrnPenResolved_r = AMAX(GovHHTrnPenTop_r, GovHHTrnPenBottom_r)$$

The bottom-up calculation of welfare transfers is parallel to that for pensions.

$$GovHHTrnWelBottom_r = Pop_r * GovHHWelPC_r^{t=1} * \frac{GDPPC_r^t}{GDPPC_r^{t=1}} * MulExp_r^{t-1}$$

The two transfer pressures are summed and compared with the total, top-down estimate of transfers, with the maximum of the two terms used as total transfers.

$$GovHHTrn_r = AMAX(GovHHTrnTop, GovHHTrnPenResolved_r + GovHHTrnWelBottom_r)$$

A proportionate share of the total transfers constitutes pensions, and welfare transfers are the residual.

$$GovHHPenT_r = GovHHTrn_r * \frac{GovHHTrnPenResolved_r}{GovHHTrnPenBottom_r + GovHHTrnWelBottom_r}$$
$$GovHHWelTot = GovHHTrn_r - GovHHPenTot$$

The split to unskilled and skilled households can be affected in subsequent years by exogenous multipliers (default values of multipliers are typically "1").

$$GovHHTTrnPen_{r,h} = GovHHPenT_r * \frac{HHINC_{r,h}}{\sum^{H} HHINC_{r,h}} * \boldsymbol{govhhtrnpenm}_{r,h}$$

$$GovHHTTrnWel_{r,h} = GovHHPWelTot_r * \frac{HHINC_{r,h}}{\sum^{H} HHINC_{r,h}} * \boldsymbol{govhhtrnwelm}_{r,h}$$

4.3 Balances and Dynamics

Having completed computations on revenue and expenditure, it is possible to compute the government balance, adjusted by foreign aid donations when given (for donors, the sign of AID is negative).

$$GOVBAL_r = GOVREV_r - GOVEXP_r + AID_r$$

That allows the update of absolute government debt and a calculation of its magnitude relative to GDP.

$$GovDebtAbs_r = GovDebtAbs_r^{t-1} - GOVBAL_r$$
$$GOVDEBT_r = GovDebtAbs_r / GDP_r$$

It is government debt as a percentage of GDP that IFs uses to build equilibrating dynamics for government revenues and expenditures.

In years beyond the first, the government debt as a percent of GDP will give rise to pressure for higher or lower levels of government revenues and expenditures. Those pressures will be conveyed via two multipliers applied to calculations of taxing and spending in subsequent years. Those multipliers are set at "1" in the first year, indicating no change in pressures initially. The rest of this section explains how those multipliers are changed over time

$$MulRev_r^{t=1} = 1$$
$$MulExp_r^{t=1} = 1$$

The first step in feeding back government debt level to pressures for increases or decreases in revenues and expenditures is to compute a target for government debt as a percent of GDP with which to compare the actual level. A function relating typical levels of debt to GDP per capita is used as the foundation of that, with the target level being the initial ratio, converging over time to the minimum of the initial ratio and the value from the function. Figure 4.7 shows debt as a percentage of GDP, once again as a function of GDP/capita (PPP), as estimated cross-sectionally using data from 2000. This function is also used in the pre-processor to fill data holes for initial values of government debt. Figure 4.8 shows the same figure for central government debt only, simply for information – central government indebtedness tends to run higher than that for general government.

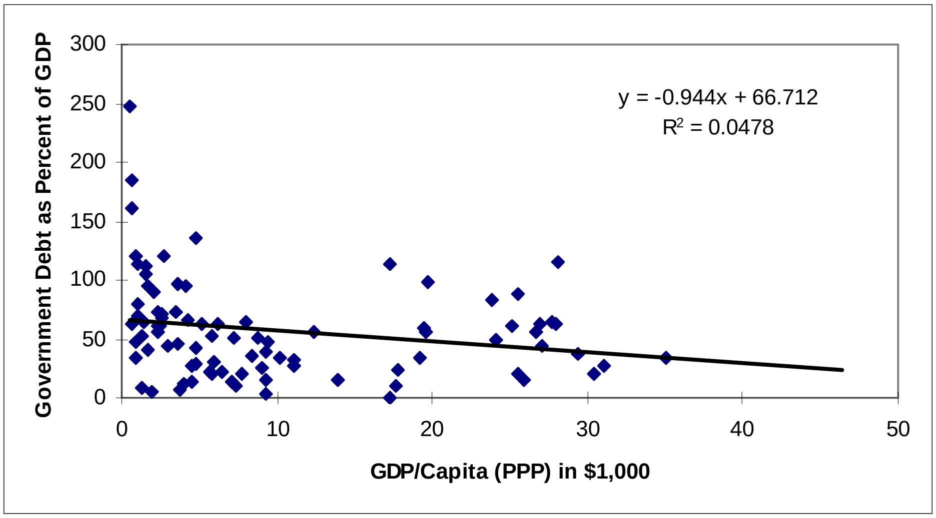


Figure 4.7. Government Debt as Function of GDP/capita (PPP)

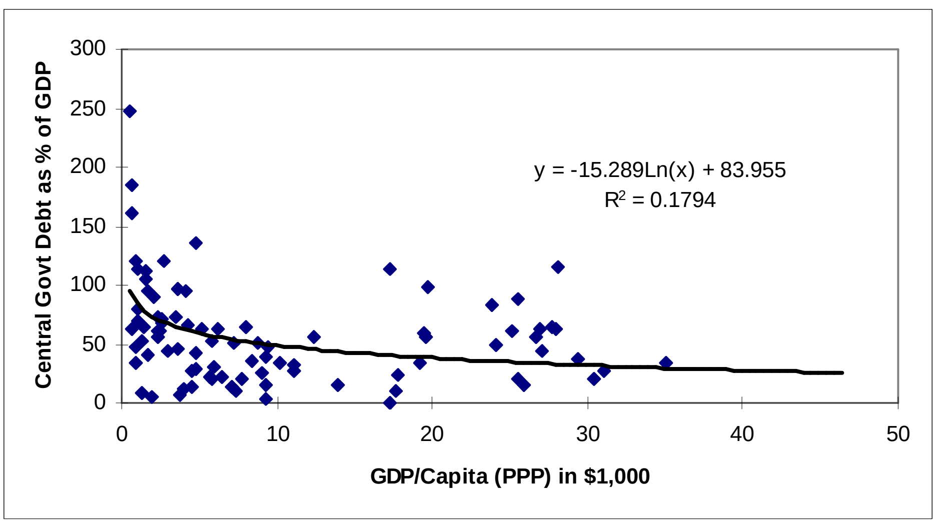


Figure 4.8. Central Government Debt as a Function of GDP/Capita

The general government function is used, along with initial empirical values of government debt when available, to set a rough "target" for government debt as a portion of GDP. As described above, convergence towards the function is assumed over time.

$$GovDebtTarget\%_r = Converge(GOVDEBT_r^{t=1}, AMin(GOVDEBT_r^{t=1}, GovDebtComp_r, 100)$$

$$where$$

$$GovDebtComp_r = AnalFunc(GDPPCP_r^t)$$

The tricky part is to get a dynamic system to chase the target over time, adjusting revenues and expenditures annually as it does so. IFs does that in this instance and in others by using an adjustment to feedback parameters based on two terms: an integral term (the absolute distance of the system from the target) and a differential term (the change in values of the target relative to the preceding year). Engineers refer to this process as a PID controller.[7] The two terms are computed as Diff1 and Diff2. A potential GDP term is used rather than the actual GDP of the year in order to protect systemic stability over time (use of GDP in the target term can set up oscillations in some feedback loops also involving GDP).

$$Diff1_r = GovDebtAbs_r^t - GovDebtTarget\%_r * GDPPot_r$$

$$Diff2_r = Diff1_r - Diff1_r^{t-1}$$

Once the two terms are available, the PID adjuster routine (ADJUSTR), described in Chapter 2, is called by IFs to convert the difference terms, modified by exogenous parameters, into a multiplier on the cumulatively-computed revenue multiplier term used in equations above.

$$Adjstr(GDPPot_r, Diff1, Diff2, \boldsymbol{elgrevdebt1}, \boldsymbol{elgrevdebt2}, Mul)$$

$$MulRev_r = MulRev_r^{t-1} * Mul$$

In the above specification, the adjuster uses two elasticities for the difference terms. In completely parallel fashion, adjustment is made to the expenditure multiplier. Tuning of the model reinforced the need for the elasticities on the expenditure side to be lower than those on the revenue side (governments are more likely to adjust revenues than expenditures).

$$Adjstr(GDPPot_r, Diff1, Diff2, \boldsymbol{elgexpdebt1}, \boldsymbol{elgexpdebt2}, Mul)$$

$$MulExp_r = MulExp_r^{t-1} * Mut$$

[7] The use of PID controllers in world models goes back at least to the first one developed for the World Integrated Model by Thomas Shook (in about 1974). The processes of their use in IFs have been facilitated by the creation of the adjustment function and by the experimental insight that, in order to maintain a system in equilibrium, the parameter on the second term is normally best set at 2 times the parameter on the first term.

5. Households and Firms

In this chapter we turn to the private sector, specifically to households and firms. The chapter begins with total income, before taxes and transfers, for firms and for each type of income. It then adds the taxes and transfers, including the ones the Chapter 4 identified with government, to identify total income.

Total income of households is split between savings and consumption and consumption is split further by sector. Total income of firms is split between gross fixed investment and savings.

5.1 Household and Firm Income

Figure 3.2 showed the division of value added between household and capital shares in the basic goods and service market module. Given that foundation, it is possible to compute household income (before taxes and transfers) by sector, and as important, to divide household income into skilled and unskilled categories. The labor coefficients (LaborF) computed from the GTAP data base and displayed earlier in Tables 4.3 and 4.4 allow that. Those sector-specific coefficients are weighted by sector-specific value added to compute the total income share going to unskilled and skilled households, respectively. Those shares are then multiplied in turn times the share of labor in GPD (as indicated by 1 minus the all-economy Cobb-Douglas coefficient on capital, computed as a sector-weighted average of the sector-specific coefficients) and that provides household income for each household type. Firm income is the remaining GDP (equivalent to the capital share), augmented by any foreign direct investment (XFDIFIN) or portfolio investment (XPORTFIN).

The income share computation also introduces a skill shift term (SkillShiftMul). The basis for the term is a presumption that over time there is a greater demand for skilled labor and a commensurately lower demand for unskilled labor. The rate of annual change has been initially set at 1%, corresponding approximately to the core level of change in multifactor productivity (analysis suggests that the rate might be a little low). There is much room for endogenization and refinement of this highly aggregate and rough specification. The importance of it lies in the re-allocation of household income away from unskilled households to skilled households. Because of the great growth in education around the world, and therefore the proportionately faster growth of skilled households, there is, in fact, credential inflation; in the absence of it, the supply of skilled labor would be increasing much faster than the demand for it and the price of it relative to unskilled labor would drop sharply. That is not happening.

$$HHINCShr_{r,h=1} = \sum^{S} Vadd_{r,s} * LaborF_{r,h,s} / SkillShiftMul$$

$$HHINCShr_{r,h=2} = \sum^{S} Vadd_{r,s} * LaborF_{r,h,s} * SkillShiftMul$$

where

$$SkillShiftMul = 1.01^{t-1}$$

$$HHIncBTT_{r,h=1} = \frac{HHINCSHR_{r,h=1}}{HHINCSHR_{r,h=1} + HHINCSHR_{r,h=2}} * GDP_r * (1 - CDALF_r)$$

$$HHIncBTT_{r,h=2} = \frac{HHINCSHR_{r,h=2}}{HHINCSHR_{r,h=1} + HHINCSHR_{r,h=2}} * GDP_r * (1 - CDALF_r)$$

$$FirmIncBTT_r = GDP_r - \sum^{H} HHIncBTT_{r,h} + XFDIFIN_r + XPORTFIN_r$$

Given household and firm income before taxes and transfers, it is possible to compute their incomes after taxes and transfers, but before any application of them. Chapter 4 identified those movements to and from government. Chapter 6 will identify those with the rest of the world, including the inflow of foreign direct investment (SFDIFIN) and portfolio investment (XPORTFIN). We need also to know the net flow of funds from firms to households, and how that is split between the two types of households. A simplifying intermediate step is to compute firm income after taxes.

$$FirmIncomeAfterTaxes_r = FirmIncBTT_r - FIRMTAX_r - FIRMGOVSS_r - INDIRECTTAX_r$$

IFs computes in the first year a firm investment ratio (FirmInvRI) as a general estimate of the portion of firm income after taxes that is used for gross capital formation. The residual is the portion that is passed back to households as dividends and interest net of new investment by those households. In the absence of data on the distribution of dividends and interests between unskilled and skilled labor-based households, equations arbitrarily assign the overwhelming share of it, namely 90%, to skilled households.

$$HHDivInt_{r,h=1} = FirmIncomeAfterTaxes_r * .1 * (1 - FirmInvRI_r^{t=1})$$

$$HHDivInt_{r,h=2} = FirmIncomeAfterTaxes_r * .9 * (1 - FirmInvRI_r^{t=1})$$

where

$$FirmInvRI_r^{t=1} = A\min(1, \frac{I_r^{t=1}}{FirmIncomeAfterTaxes_r^{t=1}})$$

At this point it is possible to compute household income adjusted by all transfer payments from government and dividends. Household disposable income (HHDispInc) is the gross income minus taxes. It is disposable income that IFs takes to the calculation of consumption and, as a residual, net savings.

$$HHINC_{r,h} = HHIncBTT_{r,h} + GOVHHTRNWEL_{r,h} + GOvHHTRNWEL_{r,h} + HHDivInt_{r,h}$$

$$HHDispInc_{r,h} = HHINC_{r,h} - HHTAX_{r,h} - HHGOVSS_{r,h}$$

[A small block on household population and income per capita has been fleshed out in the Help system and that text should be integrated here. Other changes were made in the Help system that explain the computation of VADDHHS, VADDHHU, and VADDF]

5.2 Household Consumption and Net Savings

One of the key behavioral relationships for households is the division of income between household consumption, C, and household savings (HHSAV). Given historic data, it is possible to estimate cross-sectionally a relationship between GDP per capita and average household consumption propensity.

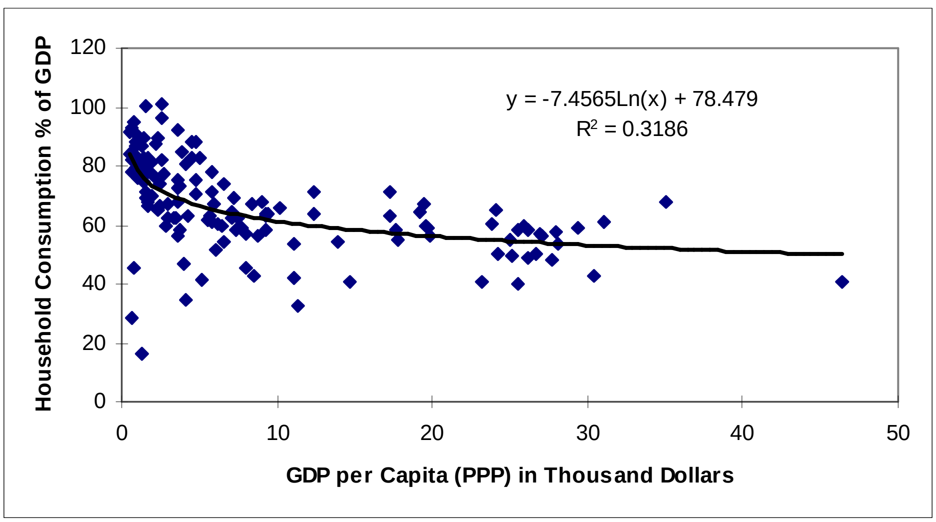


Figure 5.1. Household Consumption Relative to GDP as Function of GDP per capita.

It is, however, not possible to conceptualize and forecast household consumption independent of other expenditure components (government consumption, investment, and net trade). There are equilibrating mechanisms that cross over the goods and services market and influence agent behavior with respect to consumption, investment and savings. The rest of this chapter will gradually elaborate these mechanisms.

The core of the consumption equation, calculating a preliminary estimate of household consumption (ConsumHHPrel), multiplies a consumption ratio (CRA) as a portion of disposable household income times that income. The consumption ratio floats over time, and it will be recomputed for the next time cycle at the end of the complete formulation for household consumption. That core is multiplied over time by a ratio of the expected household consumption as a percentage of GDP from the analytic function estimated above and the percentage that would have been expected given the GDP per capita in the previous time step.

$$ConsumHHPrel_{r,h} = HHDispInc_{r,h} * CRA_{r,h}^{t-1}$$

$$C_r = \sum^{H} ConsumHHPrel_{r,h} * \frac{EstHHPer_r^t}{EstHHPer_r^{t-1}} * IntrMulC_r * Mulcon_r$$

where

$$EstHHPer_r = AnalFunc(GDPPCP_r)$$

There are two additional factors in the above equation for household consumption, and the first is an interest rate multiplier (IntrMulC). Real interest rates (INTR) – IFs does not maintain a monetary sector that would introduce nominal interest rates – are a key equilibrating variable. IFs ties interest rates to the overall balance between production and consumption in the system as indicated by the sum across all sectors of desired stocks in comparison with actual stocks/inventories (ST). Desired stocks in IFs are determined by a stock base (STBase) linked to production and consumption levels and a desired stock level (dstl) as a portion of the stock base. Interest rates rise as stocks fall relative to desired levels and fall as stocks rise above those desired levels. Interest rates enter into the equation for total household consumption such that rising interest rates depress consumption.

$$IntrMulC_r = F(INTR_r, INTR_r^{t=1}, ADJSTR)$$

where

$$INTR_r = INTR_r^{t=1} \frac{\sum^{S} STBase_{r,s} * \mathbf{dstl}}{\sum^{S} ST_{r,s}}$$

Although it should perhaps be rolled into the interest rate formulation, IFs maintains a second variable for modification of the household consumption function, a multiplier on consumption (MulCon), that helps maintain the general equilibrium between domestic savings and GDP. (It is important to understand that total savings will identically equal investment, by calculation; but it is possible that foreign savings swings can dramatically influence savings totals in a fashion that would completely crowd out or greatly expand domestic savings were there no other forces working at equilibrating domestic savings.) As domestic savings rise as a portion of GDP, they cause the consumption multiplier to rise and therefore consumption to rise.

$$MulCon_r = F(HHFirmSavR_r, HHFirmSavR_r^{t=1}, ADJSTR)$$

where

$$HHFirmSavR_r = \frac{\sum^{H} HHSAV_{r,h} + FIRMSAV_r}{GDP_r}$$

Having modified total household consumption, C, the preliminary household consumptions (ConsumHHPrel) of the different household types will no longer sum to it, so they are normalized to do so. The rates of consumption relative to disposable income can then re-computed.

$$ConsumHH_{r,h} = \frac{ConsumHHPrel_{r,h}}{\sum^{H} ConsumHHPrel_{r,h}} * C_r$$

$$CRA_{r,h} = \frac{ConsumHH_{r,h}}{HHDispInc_{r,h}}$$

It is also important to explain the initialization of those rates of consumption. In the first time step, those rates are calculated taking into account the differential propensity of different household types, currently limited to skilled and unskilled households, to consume and save. The differences are maintained over time.

The average propensity to consume in the initial year (AveConsumR) can be calculated from data.

$$AveConsumR_r^{t=1} = \frac{C_r^{t=1}}{\sum^{H} HHInc_{r,h}^{t=1}}$$

If both types of households consumed an equivalent share of income, they would consume at the average rate, as modified by the factors discussed above. Almost certainly, however, lower income, unskilled households have a higher average propensity to consume than do skilled households. In the absence of data-based knowledge about that, IFs currently uses the stylistic, and flexibly changeable function in Figure 4.7 to represent the extent of that differential, assumed to decrease as GDP/capita increases.

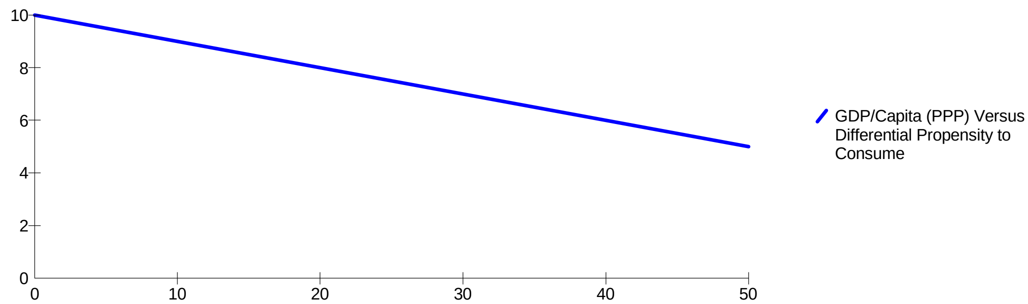


Figure 5.2. Differential Propensity of Unskilled Households to Consume – Increased Percentage of Income Consumed as a Function of GDP per Capita (PPP) in $1,000.

The consumption differential from the function adjusts the average rate for unskilled households and allows computation of actual consumption (Consum) of the unskilled and a residual calculation of consumption for the skilled (subject to tests for positive sign and reasonable size, not shown below).

The differential propensity to consume is an important feature for scenario analysis, because transfers across household types are one of the key policy levers available to governments.

$$AveConsumptionR_{r,h=1}^{t=1} = AveConsumR_{r}^{t=1} + ConsumDiffR_{r}^{t=1}$$
$$ConsumHH_{r,h=1}^{t=1} = HHINC_{r,h=1}^{t=1} * AveConsumptionR_{r,h=1}^{t=1}$$
$$ConsumHH_{r,h=2}^{t=1} = C_{r}^{t=1} - ConsumHH_{r,h=1}^{t=1}$$
$$where$$
$$ConsumDiffR_{r}^{t=1} = TablFunc(GDPPCP_{r}^{t=1})$$

$$CRA_{r,h}^{t=1} = \frac{CONSUMHH_{r,h}^{t=1}}{HHDISPINC_{r,h}^{t=1}}$$

Savings terms are calculated as residuals for all agent classes, and are determined after all income and expenditure/transfer calculations. In the case of households they are income, minus consumption and net transfers to government.

$$HHSav_{r,h} = HHInc_{r,h} - CONSUMHH_{r,h} - HHTax_{r,h} - HHGovSS_{r,h}$$

IFs does not attempt to track assets and liabilities of households over time and to add that information to the behavioral representation of them. That might be useful in the future.

5.3 Household Consumption by Sector

Consumption by sector of origin is complicated by the fact that households significantly change their pattern of consumption as their incomes increase. To capture that dynamics, IFs relies upon a linear expenditure system (LES) -- for a description of the LES approach see Taylor (1979: 219-223). Consumption in each sector of origin (CS) in the LES depends upon a minimum level of expenditure in each sector (MINEX) and the marginal budget share (MARBD) of each sector in total consumption (C) above the sum of all minimum expenditures -- the floor (FLOOR). IFs computes the parameters for this consumption function during the first time cycle of the model. The constant of 0.5 in the equation for MINEX represents a Frisch parameter (the marginal utility of income with respect to income) of -2.0. Parameters and calculations are specific to household type.

$$CSHH_{r,s,h} = MINEX_{r,s,h}^{t=1} + MARBD_{r,s,h}^{t=1} * (CONSUMHH_{r,h} - FLOOR_{r,h}^{t=1})$$

where

$$MARBD_{r,s,h}^{t=1} = \frac{\boldsymbol{engel}_s * \dfrac{\boldsymbol{CSHH}_{r,s,h}^{t=1}}{\boldsymbol{CONSUMHH}_{r,h}^{t=1}}}{\sum^{S}\left(\boldsymbol{engel}_s * \dfrac{\boldsymbol{CSHH}_{r,s}^{t=1}}{\boldsymbol{CONSUMHH}_{r,h}^{t=1}}\right)}$$

and

$$MINEX_{r,s.h}^{t=1} = \boldsymbol{CONSUMHH}_{r}^{t=1} * \left(\frac{\boldsymbol{CSHH}_{r,s}^{t=1}}{\boldsymbol{CONSUMHH}_{r,h}^{t=1}} - (.5 * MARBD_{r,s,h}^{t=1}\right)$$

$$FLOOR_{r,h}^{t=1} = \sum^{S} MINEX_{r,s,h}^{t=1}$$

Given consumption by household type and sector, total consumption by sector across households is possible, and it is necessary for the goods and services market module.

$$CS_{r,s} = \sum^{H} CSHH_{r,s,h}$$

5.4 Investment and Firm Savings

The agent class that is least developed within IFs as a class with behavioral relationships, and that instead relies on aggregated relationships is the firm. We saw much of that aggregation in Chapter 3 around the production function. With respect to investment also, the firm is represented in aggregate fashion. The equation below indicates that the core of the gross capital formation (IGCP) calculation each year is potential GDP (GDPPOT) times an investment rate (IRA) from the initial year. There are two factors that modify that core. The first is an investment rate multiplier (IRAMul) that, like the one on consumption, drives down investment when rates rise. The second is one that ties investment to a smoothed version of the SAVINGS variable. As savings rise, normally investment does also, and IFs uses a moving average to smooth savings in this relationship.

$$IGCF_r = GDPPOT_r * IRA_r^{t=1} * SmoothSavingsTerm_t * IRAMul_r$$

where

$$IRAMul_r^t = IRAMul_r^{t-1} * IntrMulI_r$$

$$IntrMulI_r = F(INTR_r, INTR_r^{t=1}, ADJSTR)$$

$$SmoothSavingsTerm_t = \frac{SmoothSavingsR_r}{SmoothSavingsR_r^{t=1}}$$

$$SmoothSavingsR_r = MovingAverage\left(\frac{SAVINGS_r}{GDPPOT_r}, .8\right)$$

Gross capital formation, although highly correlated with investment (I) is not equal to it. Investment also contains changes in stocks. It is that addition of delta stocks that brings the entire representation of the goods and services market in proper relationship with the financial representations of flows among agent classes.

Even is the basic behavior of the firm is simplified, its accounts must still balance. Firm savings is equal to firm income minus net transfers to households and government. In addition, there are positive net transfers to the rest of the world in the form of outward FDI flows (XFDIFOUT), portfolio flows (XPORTFOUT), and subscriptions to the World Bank.

$$FirmSav_r = FirmInc_r - \sum^{H} HHDivInt_{r,h} - FirmTax_r - IndirectTax_r - FirmGovSS_r$$

$$- XFDIFOUT_r - XPORTFOUT_r - XWBSUBF_r$$

5.5 Domestic Closure Between Savings and Investment

The SAM structure in IFs is really a combination of an accounting system and an equilibrating system. Just as the equilibrating mechanisms discussed above are important, it is critical to make sure that the accounting balances are maintained. One good measure of ultimate balance is the required, conceptual equality of total savings and investment. Their equality, in fact, is also reassurance that the goods and service market elements of the model are fully integrated with the broader financial ones.

Savings constitutes the residual term that assures balance between row and column totals for each agent/institution (just as investment has a residual component with respect to the goods and services market when delta stocks are added to gross capital formation). They are computed in all years, both to balance the SAM and also to provide adjustments to two stock terms, government debt and external debt, that serve as touchstones for equilibrating mechanisms in the dynamics of the model.

The documentation in this chapter explained the computations of household savings and firm savings. Chapter 4 documented government savings. The only element missing for the calculation of total savings is foreign savings.

Foreign savings come in two flavors. The first and basic flavor assumes, like all of the other savings terms, that there are no relative price changes in the economy. It maintains all of the physical balances in the economy of a specific country/region.

$$ForSav_r = X_r - M_r - AID_r$$

The total savings in each country will be the sum of the individual terms. By definition it will equal investment (I), defined as capital formation (IGCF) plus inventory stock (ST) changes. Treatment of physical balances over time, not elaborated here, assure that equality. Looking at the two variables side by side is a good test of the functioning of the SAM. Having total investment, it is also possible to compute investment by origin sector (INVS), which is needed in the goods and services market module.

$$Savings_r = \sum^{H} HHSav_{r,h} + FirmSav_r + GovBal_r + ForSav_r$$

$$I_r = IGCF_r + \sum^{S} \left(ST^{t}_{r,s} - ST^{t-1}_{r,s} \right)$$

$$INVS_{r,s} = I_r * \frac{INVS^{t=1}_{r,s}}{I^{t=1}_{r}}$$

[The relative price adjusted foreign and total savings description has been substantially fleshed out in the Help system and that text should be integrated here.]

The second flavor of foreign savings recognizes that in IFs there are relative price changes based primarily on the computation of prices in the two partial equilibrium submodels (food and energy). This second variant takes those into account in computing a relative-price adjusted foreign savings (ForSavRPA) that is then used in computations of international debt and exchange rates. It is time to move to the international side of the SAM.

6. International Behavior and Financial Flows

Strictly speaking, and with the exception of the International Financial Institutions (IFIs) like the World Bank, there is very little agency in the Rest of the World (ROW) row and column of the Social Accounting Matrix structure. What occurs there instead are various processes of balancing and equilibration. With respect to balancing, all kinds of interstate inflows, from foreign direct investment to worker remittances, must be equal to outflows on a global basis. And at the domestic level, the current account must be equal to the capital account, although with equal sign.

With respect to equilibration, stocks of foreign assets and liabilities, relative to the sizes of domestic economies, determine liquidity and solvency conditions that set in motion movements in exchange rates and compensatory financial flows. As the world has seen many times, the adjustment mechanisms can work abruptly and can overshoot. The central purpose of IFs is to facilitate thinking about long-term global change, rather than shorter-term financial crises. Nonetheless, in order to flesh out the basic social accounting matrix, it is necessary to represent many of the concepts and at least some of the processes that give rise to those shorter-term disruptions.

The structure of this chapter has three parts. The first is a discussion of the various financial flows represented and the balancing mechanisms for them. The second is a section on the World Bank as a special kind of non-domestic agent. The third is a presentation of the national current and capital accounting system, with attention to the equilibration of exchange rates. Throughout all three sections of the chapter, the discussion will, of necessity, integrate stocks and flows.

6.1 International Flows and Their Balancing

The current account includes trade in goods and services; rents, interest, profits and dividends; and current transfer payments (including foreign aid, government subscriptions to international organizations, pension payments to workers living abroad, and foreign worker remittances to their home countries). The larger of these elements have representation in IFs. Chapter 3 discussed trade and balancing of it. The Help system of IFs discusses foreign aid[8] [bring into Chapter 3 or here]. Later sections of this chapter will discuss both subscriptions to international organizations and interest, profits and dividends. The key item that this section will elaborate is worker remittances.

The capital account includes foreign direct investment (FDI), portfolio flows, IMF credits and World Bank loans, net bank lending, other net flows, and change in reserves. Note that these flows have associated stocks of importance in understanding long-term behavior. This section will discuss FDI and portfolio flows, leaving IFI flows to the next section, and changes in other lending and reserves to the equilibration section.

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[8] Bilateral foreign aid has long been represented in IFs , but we need to separate grants from loans with considerably more sophistication, and we now have the data to do so.

Worker Remittances.

Worker remittances are tied closely to the migration formulation of the IFs demographic module. It is important to know the number of foreign workers from each country and into each country (POPFOREIGN), as well as the pattern of remittances per worker, as a basis for computing remittance levels. The IFs migration module, documented in the Help system, relies heavily on UN data for past migration levels and also taps their near-term forecasts.

The data do not, however, exist for global representation of dyadic flows, that is of flows from country of origin to country of destination. IFs therefore uses a pooled approach, representing aggregate flows out of countries and aggregate flows into countries, requiring that they be balanced, but not attempting to trade dyadic patterns. The pooled approach is also used by IFs in trade (where dyadic representation would be possible), foreign aid (where it would be difficult if not impossible to obtain dyadic data), and the other financial flows discussed in this chapter (where again dyadic data are seldom available).

The specific formulation computes a global average remittance rate per worker (WWorkRemitRate) and a host-country specific ratio of remittance rate to the global one (WorkRemitRate) in the first year. In subsequent years, those rates are applied to the number of foreign workers, but adjusted by the ratio of current GDP per capita to initial GDP per capita. The outflows are assigned to inflow countries so as to maintain a global balance.

$$XWORKREMIT_r = -POPFOREIGN_r * WWorkRemitRate^{t=1} * WorkRemitRateI_r^{t=1} * \frac{GDPPC_r}{GDPPC_r^{t=1}}$$

where

$$WWorkRemitRate^{t=1} = \frac{\sum^{R} - XWORKREMIT_r^{t=1}}{\sum^{R} POPFOREIGN_r^{t=1}}$$

$$WorkRemitRateI_r^{t=1} = \frac{\frac{Abs(XWORKREMIT_r^{t=1})}{Abs(POPFOREIGN_r^{t=1})}}{WWorkRemitRate^{t=1}}$$

Initial data on worker remittances, added to the IFs database as a percentage of GDP, come from the World Bank's WDI, as do data on foreign population as a percentage of the total. The original sources were Global Development Finance and the OECD, respectively. The worker remittance series only includes data by country of receipt. In the pre-processor, remittances by countries of origin were estimated on the basis of the foreign worker series.

Foreign Direct Investment.

Firms are primarily in charge on both ends of foreign direct investment. In general, of course, the pattern is likely to be that firms direct FDI from relatively capital-rich countries to relatively capital-poor ones. Figure 6.1 below reinforces that presumption by showing the patterns found in the IFs database (using FDI flow data from WDI). The less steeply-sloped line is the relationship between GDP per capita at PPP and the stocks of FDI inflows as a ratio to GDP. The more steeply-sloped line is the relationship between GDP per capita at PPP and the stocks of FDI outflows as a ratio to GDP. Both lines are upward sloping and, in fact, countries are simultaneously larger sources and targets of investment, even relative to GDP, as they develop. Yet, roughly speaking, countries are net recipients until GDP per capita is somewhat above $20,000 and net sources thereafter.

IFs recognizes that these patterns will not be universal. Thus the algorithm that determines stocks of investment outflows is one that builds in the historic pattern of an FDI source, but that assumes convergence over long periods of time, such as a century, towards the generic pattern. The same is true for recipients and stocks of inflows. It would probably be reasonable to posit that both lines would shift to the right over time as the average per capita levels of global GDP increase. We have not built that presumption into the model at this time.

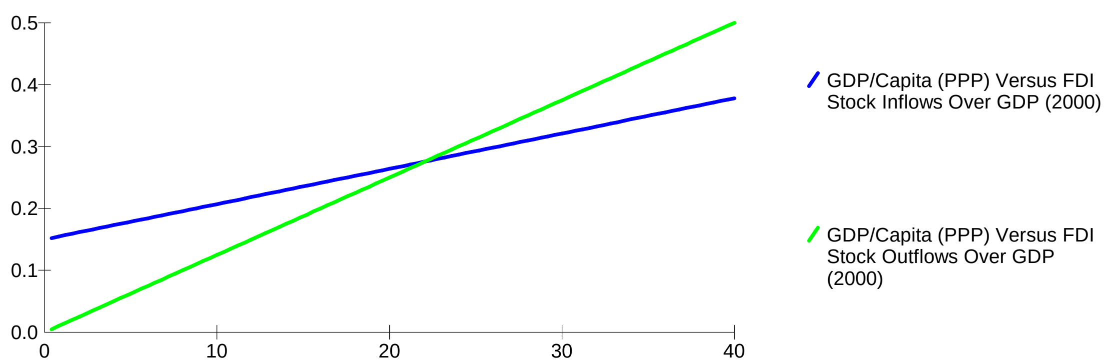

Figure 6.1. Stocks of FDI Inflows and Outflows Over GDP as a Function of GDP per Capita

In addition to the relative behavior of firms in states across the system, another behavioral issue is the overall pattern of increase or decrease in FDI flows relative to the size of the global economy. Over the last several decades FDI has grown steadily as a portion of the global capital stock and global economy. Economic historians are, however, quick to point out that the turn of the 20th century was a period of enhanced globalization of capital and that those flows then retreated for most of the 20th century before advancing again. And this century has already seen retreats relative to the year 2000. Thus the base case presumption built into IFs, based roughly on patterns of the late 1990s, is of growth in FDI flows at a rate that exceeds economic growth but that convergences towards GDP growth by 2010.

The representation of FDI in IFs builds from the concepts and general theory around FDI stocks that Figure 6.1 and the preceding discussion suggest. In each time cycle the model computes stocks of both inflows and outflows. As a first step, the expected stocks of inflows (EXFDISTOCK) are a fraction of GDP (FDIRatio), where the ratio gradually converges from the initial condition for each country (XFDIGDPIn) to the pattern of global ratios expected as a function of GDP (ExpFDIRatio).

$$EXFDISTOCK_r = GDP_r * FDIRatioIn$$

$$where$$

$$ExpFDIRatioIn = AnalFunc(GDPPC)$$

$$XFDIGDPIn_r^{t=1} = \frac{XFDISTOCK_r^{t=1}}{GDP_r^{t=1}}$$

$$FDIRatioIn = ConvergeOverTime(XFDIGDPIn_r^{t=1}, ExpFDIRatioIn, 100)$$

Exactly the same logic applies to expected stocks of outflows (EXFDISTOUT).

$$EXFDISTOUT_r = GDP_r * FDIRatioOut$$

$$where$$

$$ExpFDIRatioOut = AnalFunc(GDPPC)$$

$$XFDIGDPOut_r^{t=1} = \frac{XFDISTOUT_r^{t=1}}{GDP_r^{t=1}}$$

$$FDIRatioOut = ConvergeOverTime(XFDIGDPOut_r^{t=1}, ExpFDIRatioOut, 100)$$

Without further modification, the above formulations would result in stocks that fully determined the annual inflows and outflows. There are, however, empirical initial conditions for such annual flows that should not be ignored, especially in the early years of forecasts; the late 1990s were, for instance, a period of high flow rates that would not be captured by the above formulations.

Thus the formulation has a second step built around flows. Based on the above expected stocks of FDI inflows (EXFDISTOCK), actual stocks (XFDISTOCK) are computed using a rate of growth (FDIRIn). The user can further intervene in the stock specification with a multiplier (xfdistockm). The rate of FDI stock growth converges from an initial rate tied to empirical inflows to an exogenous rate (xfdistockr).

$$XFDISTOCK_r = EXFDISTOCK_r * (1 + FDIRIn/100) * xfdistockm_r$$

$$where$$

$$XFDISTOCKR_r^{t=1} = \frac{XFDIFIN_r^{t=1}}{XFDISTOCK_r^{t=1}} * 100$$

$$FDIRIn = ConvergeOverTime(XFDISTOCKR_r^{t=1}, xfdistockr_r, 100)$$

Again the logic is the same for outward flows and stocks.

$$XFDISTOUT_r = EXFDISTOUT_r * (1 + FDIROut / 100) * xfdistockm_r$$

where

$$XFDISTOUTR_r^{t=1} = \frac{XFDIFOUT_r^{t=1}}{XFDISTOUT_r^{t=1}} * 100$$

$$FDIROut = ConvergeOverTime(XFDISTOUTR_r^{t=1}, xfdistockr_r, 100)$$

There is, therefore, in the formulation a tension between the convergence of stock patterns to the analytic function for stocks as a portion of GDP and the convergence of them towards growth as specified in the exogenous parameter for rate of stock growth (xfdistockr). If the model user were to set the exogenous parameter to approximately the rate of global economic growth, the tension would be resolved. Many users will, however, want to override the analytic specification by using that exogenous parameter.

There is one additional element of the formulation for FDI, which is primarily in place for the purpose of model use in scenarios. It will often be desirable for a user to be able to simply specify a rate of global growth in FDI (including potentially sharp retrenchments in FDI) and impose the resulting global FDI levels (WFDI) on the above formulations, letting the above equations determine country/regional stocks and flows within the global constraint. This formulation element uses a rate of growth (WFDIR) in the ratio of FDI to world GDP (WFDIRGDP) that is set to move from 10% to 0.5% over the first 10 years of the model run. The user control over this will come in the form of a multiplier on global FDI (wfdistockm). Once WFDI is determined, it is used to normalize the country/regional calculations of stocks (XFDISTOCK and XFDISTOUT).

$$WFDI = WFDIRGDP^{t-1} * WGDP * (1 + WFDIR)$$

where

$$WFDIR = ConvergeOverTime(.1, .005, 10)$$

$$WFDIRGDP^{t-1} = \frac{WFDI^{t-1}}{WGDP^{t-1}}$$

[Note: Parameters need to be introduced for the 10% and 0.5% rates.]

The changes in the ultimate values of stocks, of course, then provide gross inflows and outflows.

$$XFDIFIN_r^t = XFDISTOCK_r^t - XFDISTOCK_r^{t-1}$$

$$XFDIFOUT_r^t = XFDISTOUT_r^t - XFDISTOUT_r^{t-1}$$

Obtaining data for initialization of the stocks and flows of FDI posed some challenges. UNCTAD's annual World Investment Report had some data on stocks, but they proved difficult to obtain electronically. We therefore turned once again to WDI 2002, in spite of the fact that the source provides only flows. It does, however, basically provide both net inflows and net outflows (XFDIFIN and XFDIFOUT). Because of the instability in these numbers over time, the last five years of data were averaged to compute initial conditions for annual flows in the model.

Integrating the flows from 1970 through 2000, on the assumption that there was relatively little FDI prior to 1970, provided estimates of stocks that seemed fairly reasonable when checked against some of the UNCTAD stock data. But because these do not necessarily yield the same totals for global inflows and outflows, the two sets of numbers were summed for their respective totals, true values were assumed to be the average, and inflows and outflows were normalized to that average. The result was initialization of FDI stocks from abroad (XFDISTOCK) and FDI stocks held abroad (XFDISTOUT). These do not necessarily yield the same totals for global assets and liabilities. Therefore, the two sets of numbers were summed for their respective totals, true values were assumed to be the average, and country-specific assets and liabilities were normalized to that average.

Portfolio Flows

The algorithm behind portfolio flows, again involving firms in large part but also introducing behavior of households, is essentially the same as that for FDI. In the absence of data on outflows, the model uses a simple step-threshold function, in which outflows do not begin for countries until GDP per capita reaches $10,000 (see Figure 6.2). As with FDI inflows, portfolio inflows rise from very low levels of GDP per capita [there is a problem with this display]. And again, model users can intervene to change either systemic growth of portfolio flows or individual country/region patterns.

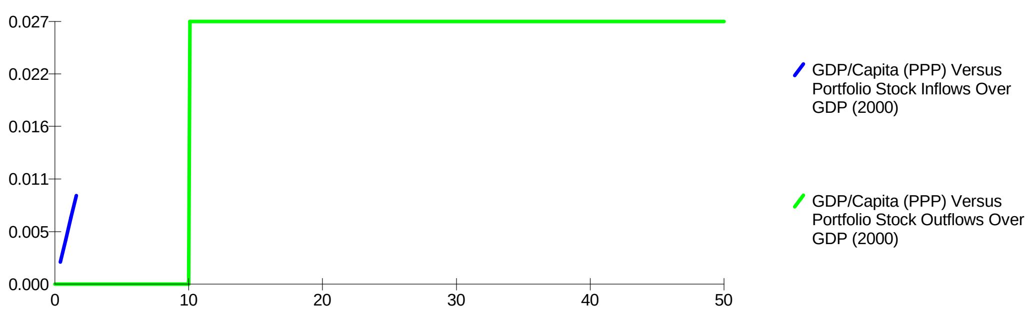

Figure 6.2. Stocks of Portfolio Inflows and Outflows Over GDP as a Function of GDP per Capita

With respect to portfolio investment, WDI provides flow data on both bond and equity investment. Again averages of the most recent five years were used to compute initial conditions for annual flows, and annual flow data were integrated from 1970 through 2000 to obtain estimates of portfolio stocks held in developing countries (XPORTFOLIO). Unfortunately, the WDI provided only flows into developing countries and the data fail to account for the source of the flows. Therefore the asset balances were assigned by GDP weight to developed countries (XPORTSTOUT).

After the logic of the stock-driven formulation is played out, the final determination of flows is identical to that for FDI.

$$XPORTFIN_r^t = XPORTFOLIO_r^t - XPORTFOLIO_r^{t-1}$$
$$XPORTFOUT_r^t = XPORTSTOUT_r^t - XPORTSTOUT_r^{t-1}$$

Ideally foreign direct investment and portfolio investment would be responsive to equilibrating mechanisms. In reality, that is not always the case. FDI and portfolio flows can be, in fact, somewhat perverse, moving from fear or greed in opposite directions to the needed balances. At this point, no linkages of any kind have been added to these flows from exchange rates, liquidity levels, or other elements of the equilibrating mechanisms to be discussed later.

[The portfolio flow description has been substantially fleshed out in the Help system and that text should be integrated here.]

Also, at this point there is no representation of dynamics for direct firm borrowing and lending across country borders. Instead there is a simple growth equation. At the very least, this equation should be parameterized for user intervention.

$$XFIRMDEBT_r^t = XFIRMDEBT_r^{t-1} * 1.03$$

6.2 International Financial Institution Agency

The international financial institutions (IFIs) are agents of importance for countries around the world. This section explains a basic agent representation of the World Bank and a less-fully elaboration representation of the IMF.

With respect to World Bank agency, the formulations of IFs fall generally into four basic decision categories: How much to loan? To whom to loan? For what purposes to loan? At what terms to loan?

Concerning the total that the bank has to loan at any given time (XWBLOANSTOT), that is a simple sum of lending capacity last year plus repayments (XWBLnRepayTot), minus new loans (XWBLnNewTot), and plus new subscriptions (XWBLnNewSubTot), the last term modified by the loan to equity ratio maintained by the Bank (xwblneqr). Repayments or the flows out of countries to the Bank (XWBLNFOUT) depend on total lending to the countries (XWBLOANS), the real interest rates charged by the Bank (wblintr) and the repayment rates in years (xwblnrepr).

The World Bank and its member countries collectively determine the rates of growth (xwbloanr) in new subscriptions (XWBSUBF). IFs does not attempt to maintain cohorts of loans to different countries. Nor does IFs track the administrative overhead of the Bank, which could significantly reducing lending capacity over time.

$$XWBLOANSTOT^{t} = XWBLOANSTOT^{t-1} + XWBLnRepayTot^{t} - XWBLnNewTot^{t}$$

$$+ XWBLnNewSubTot^{t} * \boldsymbol{xwblneqr}$$

where

$$XWBLNFOUT_{r}^{t} = XWBLOANS_{r}^{t-1} * \frac{\boldsymbol{wblintr}}{100} + \frac{XWBLOANS_{r}^{t-1}}{\boldsymbol{xwblnrepr}}$$

$$XWBLnRepayTot^{t} = \sum^{R} XWBLNFOUT_{r}^{t}$$

$$XWBLnNewTot^{t} = \sum^{R} XWBLNFIN_{r}^{t}$$

$$XWBSUBF_{r}^{t} = XWBSUBF_{r}^{t-1} * \left(1 + \frac{\boldsymbol{xwbloanr_{r}}}{100}\right)$$

$$XWBLnNewSubTot^{t} = \sum^{R} XWBSUBF_{r}^{t}$$

With respect to the countries to which it lends, IFs focuses primarily on determining flows as a percentage of GDP. This is different than the approach to representing FDI or portfolio investment in part because those representations were general with respect to agency. In the case of World Bank lending, there is much reason to believe that it does target flows based on characteristics of the borrowing country. Figures 6.3-6.5 shows three characteristics that demonstrate correlations with annual lending by the Bank as a portion of GDP: GDP per capita (PPP), the Gini coefficient of inequality, and aid that countries receive as official development assistance (ODA) from countries. A more extensive analysis is documented elsewhere (Hughes and Hossain 2003). For instance, GDP per capita and the Human Development Index (HDI) are close substitutes in correlations with Bank lending.

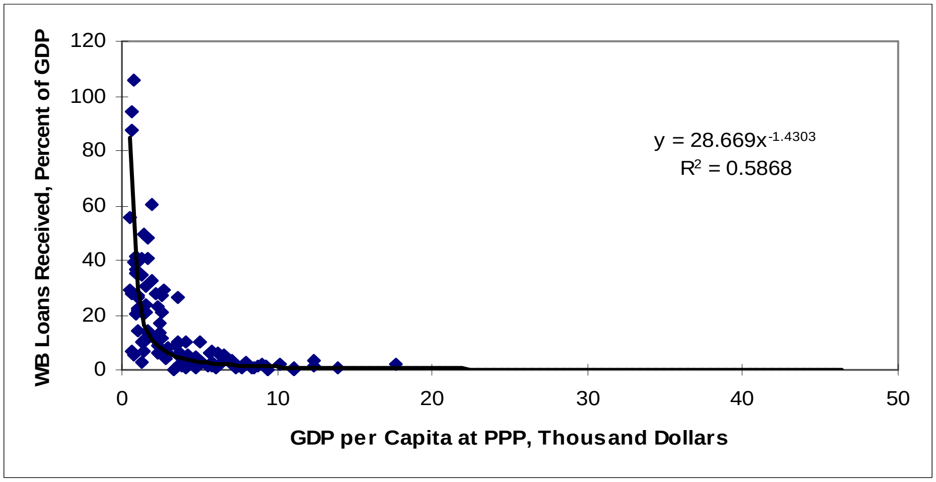

Figure 6.3. World Bank Lending as a Function of GDP per Capita

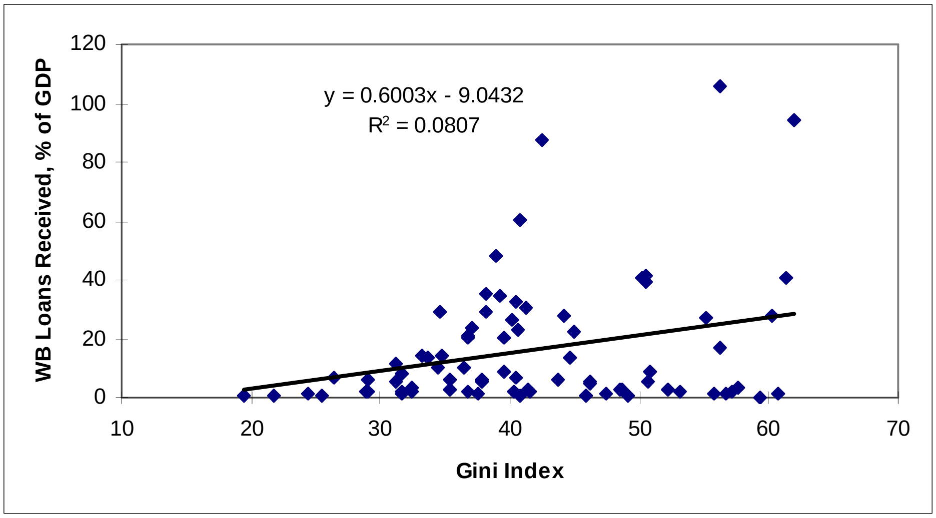

Figure 6.4. World Bank Lending as a Function of Gini

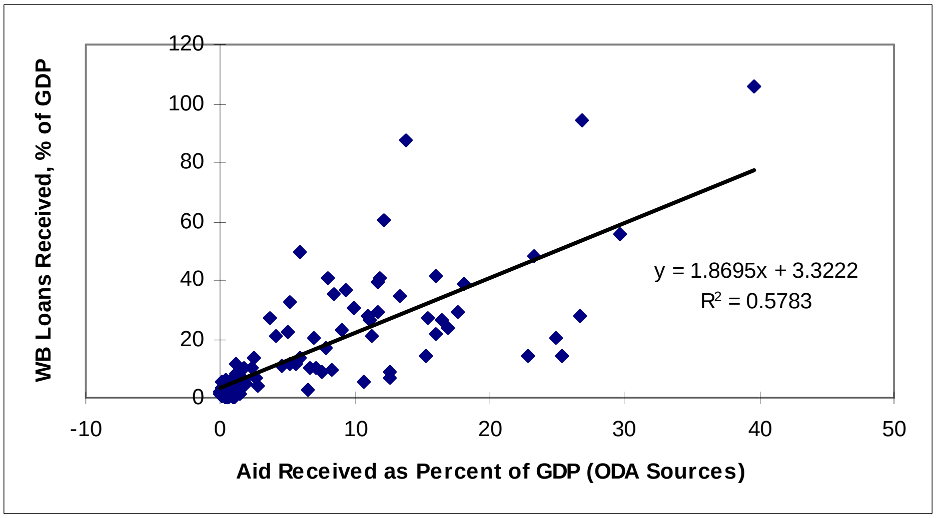

Figure 6.5 World Bank Lending as Function of Other Aid Received

After extensive exploration, it was decided to add to IFs a three-variable representation of Bank decision-making concerning the countries to whom it lends. Table 6.1 shows the specifics of the representation, which the user can change via the model interface.

Dependent Variable = XWBLoans%GDP(MOSTRECENT) (None)
Independent1 Variable = GDP2000PCPPP(MOSTRECENT)/ 1000 (X^-1.4303)
Independent2 Variable = GiniExtended(MOSTRECENT) (None)
Independent3 Variable = AidRec%GNI(MOSTRECENT) (None)
Coef_of_X1: Independent1 = 14.3226453683746
Coef_of_X2: Independent2 = .155125180072365
Coef_of_X3: Independent3 = 1.42291125572107
Y_Intercept = -5.70110747105759
R-Square = .743879538662298

Adj R-Square = .734153445193778
F-Value = 76.4828696197455
Beta_of_X3: Independent3 = .55768975591725
t-Value_of_Y-Intercept = -1.08641015957372
t-Value_of_X1: Independent1 = 5.04724869198303
t-Value_of_X2: Independent2 = 1.2373176826121
t-Value_of_X3: Independent3 = 7.54484575351746

Table 6.1. A Three-Variable "Explanation" of World Bank Lending

The function detailed above provides the foundation for a three-step representation of the country-specific lending flows from the bank (XWBLNFIN). The first step is to compute a base value for flows to each country, simply by scaling up each country's initial lending receipts by the growth in total World Bank lending. Computing such a base is valuable because it preserves the bases for lending that are not captured in the predictive formulation (the three variables capture about three-fourths of the bases).

$$XWBLnFInBase_r^t = XWBLNFIN_r^{t=1} * \frac{XWBLOANSTOT^t}{XWBLOANSTOT^{t=1}}$$

The second step is to compute an adjusted forecast of lending, taking into account the changes in the predictive factors from initial values. The adjusting factors come into the equation as a ratio of the purely predicted lending rate in the current time period over that rate in the initial period.

$$XWBLnFInPred_r^t = AnalFunc(GDPPCP_r\ , GINIDOM_r\ , AIDPERGDP_r\ )$$

$$XWBLnFInAdj_r^t = \frac{XWBLnFInPred_r^t}{XWBLnFInPred_r^{t=1}} * XWBLnFInBase_r^t$$

The third and final step is to normalize the adjusted forecasts to the total of new World Bank lending. This step also allows the user to force changes in lending to specific countries via an exogenous multiplier (xwblnfinm).

$$XWBLNFIN_r^t = XWBLnFInAdj_r^t * \frac{XWBLOANSTOT^t}{\sum^R XWBLnFInAdj_r^t} * \boldsymbol{xwblnfinm}_r$$

The outstanding loan portfolio for each country can then be updated.

$$XWBLOANS_r^t = XWBLOANS_r^{t-1} + XWBLNFIN_r^t - XWBLNFOUT_r^t - XWBSUBF_r^t$$

The third decision of the World Bank as agent was specified to be the target sector of loans within recipient countries. In large part because of the other representations within IFs, five such targets are specified: education, health, unskilled worker households, skilled worker households, and other uses. At this point in model development a single parameter (xwbsectar) has been added with default values that draw upon data gathered about past Bank practice to guide flows to uses within recipient countries. A final adjustment term is put unto that equation based upon algorithmic analysis in the first year; for instance, if it is found that supposed World Bank lending to the education sector exceeds government spending in that sector, the adjustment factor reduces it.

$$XWBFLOWS_{r,ft}^{t} = XWBLNFIN_{r}^{t} * \frac{\boldsymbol{xwbsectar}_{t.ft}}{100} * XWBFlowsAdj_{r,ft}^{t=1}$$

The fourth and final set of decisions concern the terms of the lending. Again, parameters exist to change interest rates (xwblintr) and repayment periods (xwblnrepr). Currently, returns of funds to the World Bank and the IMF are assumed in the base case to be at the rate of 5% of principal each year, with 3% real interest payments, about the rate of global economic growth.

The IMF representation is a considerably simplified version of that for the World Bank. It determines in the same manner how much credit the IMF has to offer. And it determines the target of credits based on the scaling up of initial credits, the process that computed on a base calculation for the World Bank. There is no representation of IMF agency based on analysis around the drivers of its credit offering over time (such as liquidity problems of recipients). This could be developed analogously to the representation in the World Bank, although the real-world IMF process is more politically charged than are Bank lending decisions.

[The IMF description has been substantially fleshed out in the Help system and that text should be integrated here.]

There were many data-related issues and decisions made to initialize the World Bank and IMF representations. The WDI 2002 database provides information on annual loans from the World Bank in two categories, those of the International Bank for Reconstruction and Development (IBRD) and those from the International Development Bank (IDA). The latter loans tend to have more concessional terms than do the former. Similarly, the database provides information on annual credits from the IMF, dividing them into concessional and non-concessional.

For the purposes of the SAM at this stage, the pre-processor sums the two types of loans and two types of credits into a total annual lending by the Bank and total credit flow from the IMF. Because these values tend to fluctuate substantially from year to year, and because the final years of the 1990s were a rather unusual period in global financial markets, the values set for initialization of forecasts were calculated from 5-year averages of loans and credits received as a percent of GDP from 1996 through 2000, with the average rate then applied to the GDP of developing countries in 2000.

Unfortunately, the data only indicate net flows. For purposes of the dynamics of the model, it is important to distinguish repayment of loans or credits and interest on loans from new inflows. Net flows from the World Bank were decomposed into estimates of inflows (XWBLNFIN) and outflows (XWBLNFOUT) by estimating the value of repayments (outflows) based on the stock of loans from the Bank; initialization of stocks will be discussed below. The estimate of outflows assumed a 20-year life on loans and therefore 5% annual repayment, as well as a 3% interest rate via parameters that have now been made flexible for intervention by users. New inflows are then calculated as net flows minus the outflows. Exactly the same process was followed for IMF credits.

The pre-processor turns next to lending of the World Bank and credits from the IMF, collectively the International Financial Institutions (IFIs). It again uses WDI 2002 data for initial conditions of total loans held by borrowing countries (XWBLOANS). Nulls are filled with zeros. The same is done for IMF credits (XIMFCREDIT). In both cases, it is assumed that the bulk of funds loaned by the two IFIs come from subscriptions that ultimately constitute assets of developed countries. The pre-processor assigns assets by size of GDP.

6.3 International Financial Accounting and Equilibration

The discussion of the domestic side of the SAM representation explained equilibrating dynamics of two kinds: those around goods and service markets and those around financial assets and liabilities of agent-classes, especially government debt. On the international side of the SAM structure, the key equilibrating dynamic centers on the total level of international debt of a country. Changes in foreign reserves and short-term governmental borrowing play important short-term buffering roles Exchange rates are a key longer-term equilibrating variable.

Conceptual foundations for the dynamics build largely on two concepts discussed earlier in this chapter: current account balance (CURACT) and capital account balance (CAPACT). Although in terms of definition they are equal with opposite signs, it is more complicated than that. Current account equals the trade balance (TRADEBAL) of relative-price adjusted exports (XRPA) minus imports (MRPA), plus the net outflow of foreign aid (AID), plus foreign workers' remittances to home countries, plus pension payments to retirees living abroad, plus the rents, interest, profits, and dividends paid on past capital inflows. Capital account equals the net inflow of underlying capital flows (the change in stocks), both long-term and short-term. The long-term includes foreign direct investment; the short term includes hot money in bank deposits and T-bills.

Although the current and capital accounts must balance, the balance often relies in the very short term on residual changes in stocks, namely reserve holdings and reactive government borrowing. In the longer-term exchange rate and interest rate fluctuations help maintain the balance by affecting the dynamics of the more slowly adjusting trade and longer-term financial flows.

IFs brings together most of these elements in its representations of the international financial dynamics around the SAM. It computes the current account balance from the elements indicated above, except that pension liabilities abroad are not represented. Workers' remittances were incorrectly placed into the capital account formulation discussed below; they sign will be changed and they will be moved to the current account.

$$Curact_r = XRPA_r - MRPA_r + AID_r - Interest_r$$

where

$$Interest_r = \mathbf{lintr} * (IFIDebt_r + FDIDebt_r + PortDebt_r + FirmDebt_r + GovtDevt_r)$$

where

$$IFIDebt_r = XBLOANS_r + IMFCREDIT_r$$

$$FDIDebt_r = XFDISTOCK_r - XFDISTOUT_r$$

$$Portdebt_r = XPORTFOLIO_r - XPORTSTOUT_r$$

$$FirmDebt_r = XFIRMDEBT_r$$

$$GovtDebt_r = XGOVTDEBT_r$$

Most of the above formulation is focused on determining the net interest, profit, dividend flows, which are specified as an exogenous interest rate (lintr) times the net stocks of assets mostly discussed earlier.

IFs then computes a *limited* (or partial) capital account balance from the elements of the capital account over which the government normally has least direct control [as noted earlier, worker remittances need to be moved to the current account]. The limited capital account balance purposefully excludes the two equilibrating elements of changes in reserves and short-term government compensatory borrowing.

$$CapActLim_r = IFIFlow_r + FDIFlow_r + PortFlow_r + XWORKREMIT_r$$

where

$$IFIFlow_r = XFDIFIN_r - XFDIFLOUT_r$$

$$FDIFlow_r = XWBLNFIN_r - XWBLNFOUT_r + XIMFCRFIN_r - XIMFCRFOUT_r$$

$$PortFlow_r = XPORTFIN_r - XPORTFOUT_r$$

The model makes no assumption that it can anticipate a government's relative choice between changes in reserves and changes in short-term government borrowing (XGOVTDEBTB) in order to achieve real balance between the current and capital accounts. Instead, it assumes that reserves will grow at a relatively steady rate over time [not yet implemented; change in reserves is now 0] and arbitrarily uses government debt as the buffering mechanism. Total governmental debt is now set as the short-term borrowing plus longer-term IFI credits and loans.

$$XGOVTDEBTB_r^{t+1} = XGOVTDEBTB_r^t - CURACT_r - CapActLim_r + DelRserves_r$$

$$XGOVTDEBT_r^{t+1} = XGOVTDEBTB_r^{t+1} + XIMFCREDIT_{rt} + XWBLOANS_r^t$$

Total external debt is the sum of governmental indebtedness and firm debt.

$$XDEBTRPA_r^{t+1} = XGOVTDEBTB_r^t + XFIRMDEBT_r^t$$

Reserves change with delta reserves [not yet developed] and liquidity is definitionally the current account balance over reserves.

$$XRESERVES_r^{t+1} = XRESERVES_r^t + DelRserves_r$$

$$where$$

$$DelRserves = 0$$

$$LIQUIDITY_r = \frac{CURACT_r}{XRESERVES_r} * 100$$

Exchange rates are a function of external debt, using a PID controller mechanism to maintain relative balance with a target of zero over time.

$$XDebtTargetPerGDP_r = ConvergeOverTime(XDebtIRat_r, UltimateTarget, 100)$$

$$where$$

$$XDebtIRat_r = \frac{XDEBTRPA_r^{t=1}}{GDPPOT_r^{t=1}}$$

$$UltimateTarget = 0$$

The exchange rates are actually computed and used in advance of trade balances and much else. They therefore must draw on debt data from a year earlier.

$$EXRATE_r = ADJSTR(PIDController, XDebtTargetPerGDP_r^{t-1})$$

[The exchange rate description has been substantially fleshed out in the Help system and that text should be integrated here.]

Once again, initialization of concepts with data was a challenge. The first step in the initialization of all financial stocks within the pre-processor is the processing of data on total external debt of countries (XDEBTRPA). The raw data came from the WDI 2002. Null values for developing countries are filled with zeros. Unfortunately, external debt data from the WDI are for developing countries only and there are no corresponding asset data for the lending countries, presumably mostly developed countries. As in other such instances, the pre-processor now assigns the total of external debt of developing countries to developed countries, defined for this purpose as countries with no external debt indicated and GDP per capita of $10,000 or more. The assignment is proportional to GDP of the more developed countries. Both the presumption that more developed countries are primarily asset holders and the proportional assignment are clearly inaccurate. The rationale for both is that the resultant stock assumptions, on average, are almost certainly better than assumptions that asset stocks of such countries are uniformly zero. Further, the dynamics of the model will be more greatly determined by change in stocks from initial levels than by the absolute values of them. Nonetheless, data on these assets would be highly desirable.

The next step is the reading of publicly-guaranteed and not-guaranteed debt, both of which are assumed to be held by firms and which are summed to obtain total external firm debt (XFIRMDEBT). Holes are filled with zeros because levels of debt are often very small and non-reporting often will imply debt levels near zero. Because the data only cover stocks of debt held by developing countries as liabilities, the stocks as assets were once again allocated to developed countries, specifically to firms within them, according to GDP size.

Not all of government debt is external. In fact, especially for developed countries, households and firms often hold much of it. In order to divide government debt between foreign and domestic holders of it, we first compute government external debt. This is done by assuming that households do not have any real external debt, so that all external debt not assignable to firms is governmental external debt.

$$XGOVTDEBT_r = XDEBT_r - XFIRMDEBT_r$$

The assumption was again made that all of this debt should be assigned as assets to governments in developed countries. Rather than assigning it on the basis of GDP, however, it was assigned on the basis of official development assistance (ODA). The OECD and WDI both provide data on ODA. Because significant portions of ODA come as loans rather than grants, the assignment of the government asset offset of developing government debt based on the size of ODA makes sense.

Governmental domestic debt is calculated as total government debt minus the external stock.

$$GOVTDEBTD_r = TotGovtDebt_r - XGOVTDEBT_r$$

The WDI 2002 data set contained data on reserve holdings (XRESERVES). These are read by the pre-processor and null values are assigned zeros.

6.4 Concluding Comments: SAM and the Broader Model

The universal SAM structure in IFs is at a relatively early state of development (it has come into being over the last year). At this point there is an increasingly strong empirical basis, but there are also more arbitrary assumptions and rough edges than will be the case as it evolves. Fortunately, refinements and extensions are much easier than creating a new set of structures.

In addition to structural elements, one of the important features of the International Futures modeling system is the ability via the user interface to display easily both historic data and forecasts and to create fairly quickly scenarios with one or multiple parameter changes. The next chapter takes advantage of some of this capability to provide some early analysis of the two social issues identified earlier: pension funding in developed countries and more general social protection in developing countries.

7. An Overview of Use of IFs with the Universal SAM

This chapter gives a birds-eye view of the SAM structure within the IFs model from the user's point of view.

7.1 Flows in the SAM

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 7.1 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 may 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.

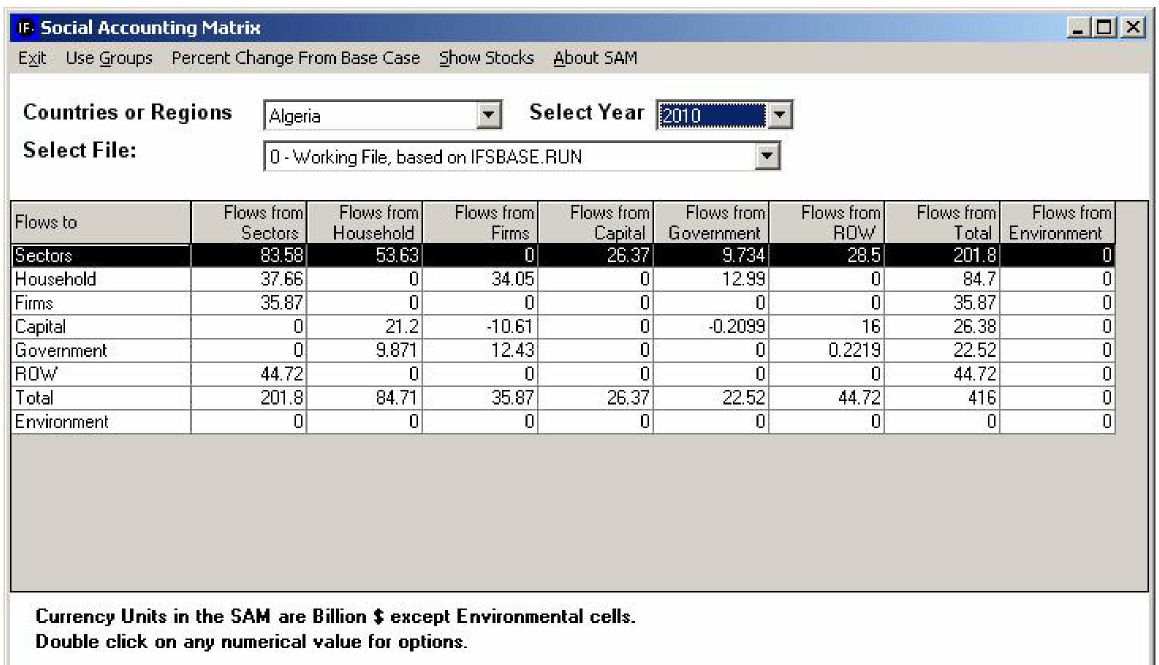

Figure 7.1. Rolled-Up Social Accounting Matrix (SAM) from IFs

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 provide households transfer payments of $13 billion dollars while households provide government with $9.9 in various forms of taxes or other payments.

It is also conventional to include in the upper left-hand cell some representation of economic sectors or commodities tied to basic input-output analysis, and then to augment this with flows between those economic sectors and among several different categories of social agents or institutions. The most common of these agents or institutions is some representation of households, of firms/businesses, and of government. In addition we often see a representation of a capital account and of interactions with the rest of the world (ROW). 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).

Clicking on any non-zero cell elicits a pop-up box (not shown above) with three options. The first is to obtain some information about the contexts of each cell, many of which have multiple underlying elements. The second is to expand the cell, if there are, in fact, multiple element rolled-up into the cell. For instance, clicking on the Sector by Sector column and selecting the expand option brings up the table in Figure 7.2. The IFs economic model in its current configuration 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 $3.3 billion from manufactures to energy.

Sectors, Sectors: Algeria, 2010

Exit

	Agriculture	Energy	Materials	Manufactures	Services	ICTech
Agriculture	3.954	0.0044	0.017	1.302	1.141	0.0028
Energy	0.1891	4.961	0.3581	3.337	0.6477	0.0584
Materials	0.1267	2.25	3.168	4.686	0.61	0.0628
Manufactures	0.9449	7.236	0.8689	8.525	5.353	0.2634
Services	2.283	8.136	2.78	4.51	14.19	0.9094
ICTech	0.0342	0.0318	0.0754	0.0696	0.4243	0.0747

Figure 7.2. Intersectoral Flow Elaboration.

The second option provided when clicking on a cell is to see 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 7.3 (for whatever horizon the user has previously designated, potentially out to 2100). The three elaborated entries in Figure 7.3 are general taxes paid from firms to government, firm contributions to social security/pension schemes managed by the government, and indirect taxes.

Sectors, Capital

Continue Refresh Graph Print Save Percent Filter

	FIRMTAX[0]	FIRMGOVSS[0]	INDIRECTTAX[(
	Algeria	Algeria	Algeria
Year	Billion $	Billion $	Billion $
2000	.609	.231	4.909
2001	.618	.234	4.982
2002	.711	.27	5.731
2003	.784	.297	6.315
2004	.911	.345	7.34
2005	1.021	.387	8.224
2006	1.088	.412	8.764
2007	1.182	.448	9.524
2008	1.23	.466	9.912
2009	1.266	.48	10.20
2010	1.317	.499	10.61
2011	1.308	.496	10.54
2012	1.395	.528	11.24
2013	1.416	.536	11.41
2014	1.47	.557	11.84
2015	1.581	.599	12.74
2016	1.603	.607	12.92
2017	1.716	.65	13.82
2018	1.823	.691	14.69
2019	1.849	.701	14.90
2020	1.946	.737	15.68
2021	2.014	.763	16.23
2022	2.081	.788	16.77
2023	2.136	.809	17.21
2024	2.205	.835	17.76
2025	2.279	.863	18.36

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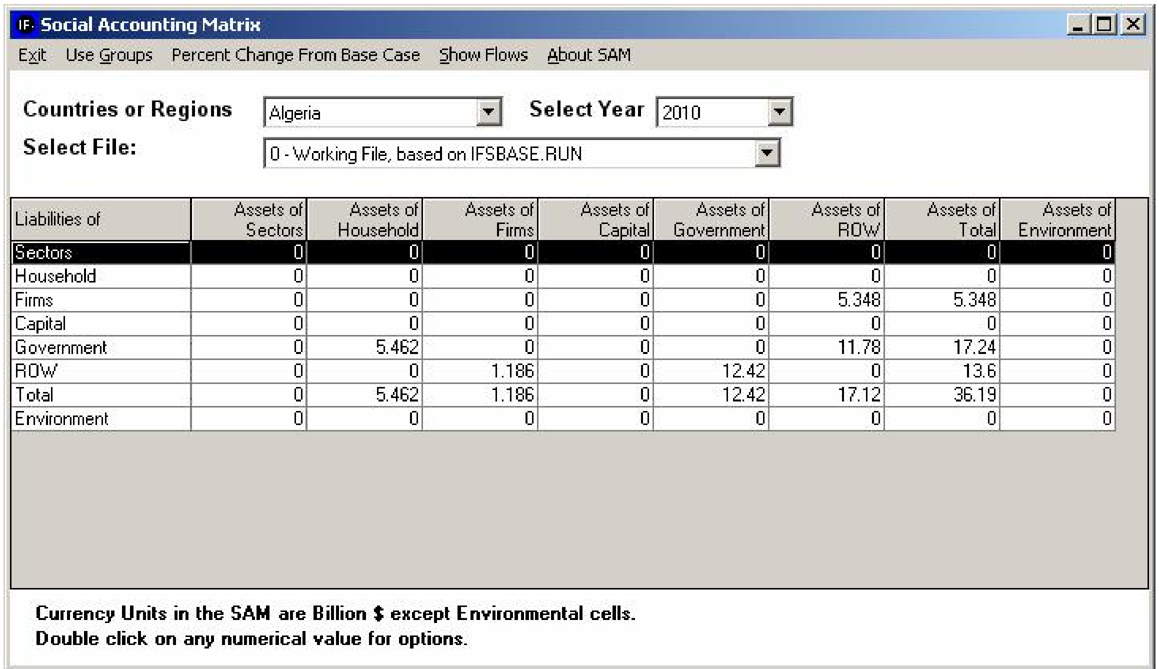
Figure 7.3 Elaboration of Firm to Government Flows.

Algeria is one of the worst possible countries that could be selected for display of data from the modeling system, because so few data are available in the sources that IFs draws upon.

7.2 Stocks in the SAM

As Chapter 2 discussed, many of the flows in the SAM augment or decrement underlying stocks. And many stocks, in turn, motivate agent-class behavior that affects flows over time. Figure 7.4 shows the emerging stocks matrix that a model user can see by clicking on the Show Stocks toggle from the window shown in Figure 7.1. The options for clicking to see explanations about cells, elaborations of them into underlying elements, and presentations of them over time are identical to the options for flows.



Liabilities of	Assets of Sectors	Assets of Household	Assets of Firms	Assets of Capital	Assets of Government	Assets of ROW	Assets of Total	Assets of Environment
Sectors	0	0	0	0	0	0	0	0
Household	0	0	0	0	0	0	0	0
Firms	0	0	0	0	0	5.348	5.348	0
Capital	0	0	0	0	0	0	0	0
Government	0	5.462	0	0	0	11.78	17.24	0
ROW	0	0	1.186	0	12.42	0	13.6	0
Total	0	5.462	1.186	0	12.42	17.12	36.19	0
Environment	0	0	0	0	0	0	0	0

Figure 7.4 Stocks in the SAM

7.3 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 7.5 (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. The $73.53 billion value shown for 2010 therefore must be and is equal to the sum of the deliveries of the sectors to households and firms shown in Figure 7.1.

	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	-.01	.697
2001	30.96	18.62	49.54	-.005	.696
2002	31.52	19.13	51.79	-.005	.699
2003	32.09	19.63	52.55	-.004	.698
2004	32.67	20.13	55.33	-.002	.702
2005	33.25	20.64	58.68	-.002	.707
2006	33.83	21.15	60.69	.001	.71
2007	34.41	21.67	64.11	-.001	.715
2008	35.00	22.20	67.13	.002	.72
2009	35.58	22.73	69.81	.003	.724
2010	36.15	23.27	73.53	.004	.73
2011	36.73	23.80	74.80	.006	.731
2012	37.30	24.33	79.37	.006	.737
2013	37.87	24.86	82.24	.01	.741
2014	38.43	25.39	85.00	.01	.745
2015	38.98	25.92	90.68	.011	.753
2016	39.53	26.34	92.91	.013	.756
2017	40.06	26.76	97.28	.011	.761
2018	40.60	27.17	102.9	.013	.768
2019	41.12	27.58	104.3	.015	.769
2020	41.63	27.97	106.3	.011	.77
2021	42.13	28.38	107.3	.012	.769
2022	42.63	28.78	107.9	.012	.767
2023	43.12	29.16	108.0	.011	.765
2024	43.60	29.54	108.9	.011	.764
2025	44.07	29.90	111.1	.013	.766

Figure 7.5 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, as discussed in Chapter 4, the model has 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 7.5 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 effectively linked to both demographic and economic representations.

8. Analysis

[Note: the analysis presented here was developed for the January, 2003, version of this document and not updated in the most recent version.]

The purpose of this chapter is to begin an analysis that will continue over some time. The combination of full demographic model, extensive economic model, and SAM representation provides capabilities that allow extensive analysis of social issues. This chapter lays some initial foundation for such analysis, focusing first on issues around aging and pension plan funding and second on broader issues of social safety nets and social protection in the developing world. The focus in this chapter is on the base case of the model, leaving scenario analysis for later.

8.1 Pensions and the Aging in Chapter 2 of the Great Demographic Transition

For most of the last five decades, any discussion of a population crisis had a very clear referent. After World War II the population growth rates of most economically Less Developed Countries (LDCs) rose sharply in the face of rapid declines in mortality and, initially, little or no decline in fertility. Demographers understood that declines in fertility towards an equilibrium were ultimately likely to occur as they had in Europe, but the pace of such adjustment was uncertain and the economic and social consequences of rapid population growth in the interim were understood to be significant and, on the whole, detrimental.

LDCs like India began programs to accelerate fertility declines, supported initially by the United States and with continued support by other developed countries. The United Nations and a variety of non-governmental organizations further contributed to the development of a global regime that continues to focus on the completion of what might be called chapter 1 of the great global demographic transition: the transition from high death and birth rates to low death and birth rates that began in the early 1800s in Europe and has now spread around the world. In fact, the pace of change has surprised many demographic forecasters and long-term world population forecasts have been falling for some time.

As the 20th century began to draw to a close, however, the referent of the expression "population crisis" began to be less clear. Below replacement fertility rates have become common in large numbers of countries in the economically more-developed world and life expectancies have continued to climb.

Even under circumstances of replacement fertility rates, dependent populations of retirement age were certain to grow in many countries relative to dependent populations of youths. Fertility rates below replacement have accelerated that shift in relative size. Moreover, it is simple to extrapolate cohort structures and see that many countries now face absolute growth in total dependent population, concentrated very heavily in retirement years.

It might be reasonable to label the period that we are entering "chapter 2" of the great global demographic transition. Like chapter 1, a significant and, in fact, growing imbalance will characterize the first phase of chapter 2. In chapter 1 the growing imbalance was a surplus of birth to death rates, which lead to overall growth in population and especially major growth in the relative size of youth populations. In phase 1 of chapter 2 the growing imbalance is a deficit of births relative to replacement rates, which is begin to give rise to overall decline in population and especially rapid relative growth of aging populations. In phase 2 of chapter 1 there was an equilibrating movement of birth rates toward death rates. We would expect a similar equilibrating adjustment later in chapter 2, this time of higher birth rates. Yet the demographic effects of the first phase of the current chapter are very likely to dominant patterns of the next 50 years, with growing imbalance throughout much of it.

Demographics change sufficiently slowly and demography is sufficiently well-developed so that the forecasts of the first phase of chapter 2 are now well-known, even if the mechanisms by which the transition to the second and equilibrating phase might occur are very much in dispute (see O'Neill and Balk 2001; Bongarts and Bulatao 2000). Although it would be folly to declare certainty concerning the pattern of growth in imbalance, we have very much moved now into a period of attempting to understand and address the consequences of growing imbalances.

As the imbalances grow and the awareness of them becomes even more pervasive, the alarm concerning them is becoming more strident and the proposals for addressing issues more active. One of the most obvious consequences of a growing aged population comes from the fact that the economically developed world has spent more than a century (at least since the days of Bismark) developing a governmental support system for retired citizens. While government also has a fiscal responsibility for dependent-aged youth (primarily education), the fiscal responsibility for retirement-aged population has come often to be of greater magnitude, involving both pension and health benefits. Therefore the current focus of concern is on governmental financial capability to address the growing imbalances (see the literature references in the first chapter of this report).

Our intent here is to add to this growing discussion with analysis that is possible using International Futures (IFs). As discussed above, that model incorporates, among other modules, a full cohort-component representation of population, a general equilibrium-seeking model of economies, and a social accounting matrix representation of financial flows across households, firms, and the government. It draws upon a data base for 164 countries and can allow us to look at those countries individually or in flexible aggregations.

Such a model adds value to analysis in three ways. First, it facilitates the analysis of uncertainty around mid- and longer-term forecasts of the magnitude of the issue by allowing us to develop scenarios based in differing assumptions concerning key driving variables: in particular the pattern of future fertility and the longevity of the aged population, but also secondary drivers such as migration patterns.

Second, it allows undertaking a fairly wide and integrated analysis of the consequences of the changing demographic patterns. As with other studies, a significant focus here will be on fiscal implications of aging. The availability of a social accounting matrix representation will, however, also allow analysis of the possible broader consequences for the resources of households and firms (and possible changes in savings/investment patterns). Similarly, the integration into the system of an economic module will allow investigation of some of the economic consequences of changes in the size of the labor force. It will be useful also to speculate about the implications of the changes for the advance of productivity in impacted economies.

Third, the modeling system will facilitate probing of the consequences of some of the recommendations made for addressing the challenges of the transition. What might be policy leverage with respect to fertility? With respect to retirement ages, women's participation rates, or human capital development? With respect to migration?

This paper, and particularly early drafts of it, present the beginnings of analysis that will unfold over time.

8.1.1 The Demographic Context of the Aging/Pension Issue

A useful beginning focus is on dependency ratios, looking at where dynamics of demographic and economic systems appear to be taking the world (at the same time, recognizing two primary uncertainties around retirement age and longevity and further uncertainties around fertility transition and migration). Analysis in Chapter 9 will return to the global, regional, and selected country forecasts of this section with alternative assumptions about retirement, longevity, and fertility.

The base case of IFs shows clearly the unfolding of aging/pension issues at a global level. Two types of dependent population will be of approximately comparable size by 2050.

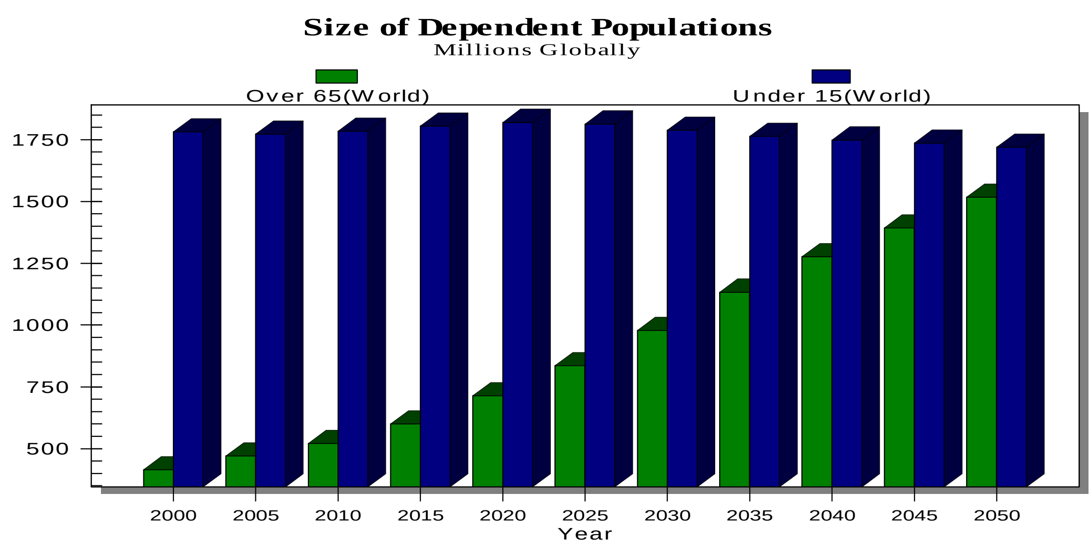


Figure 8.1 Size of Global Dependent Populations: Over 65 and Under 15

The pension issue is, of course, especially great in OECD countries where the dependent population curves will cross in 2-3 decades and the aged population will just keep growing.

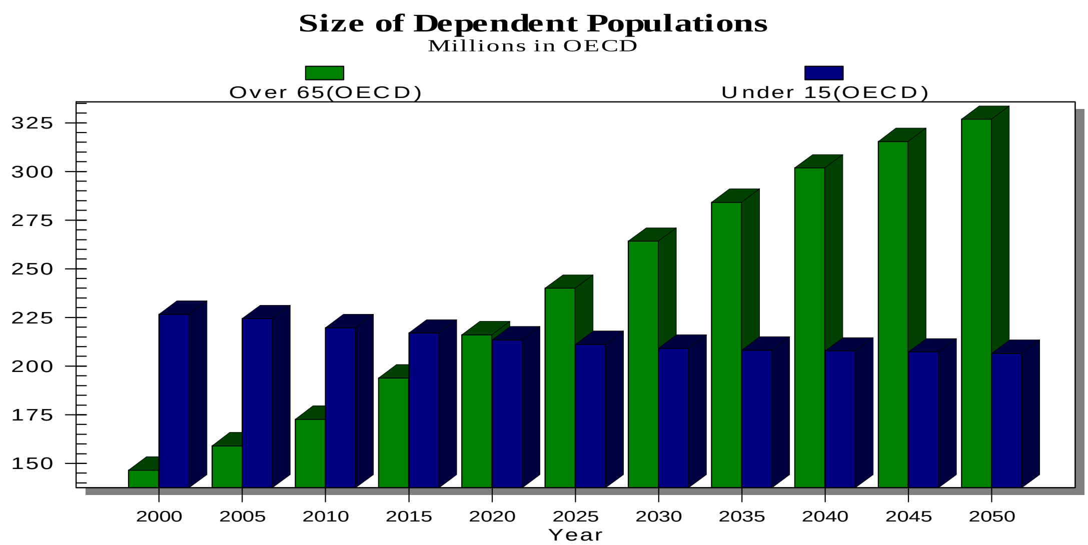


Figure 8.2 Size of OECD Dependent Populations: Over 65 and Under 15

In the European Union the future is already arriving in this decade as the aged population exceeds the young dependent population.

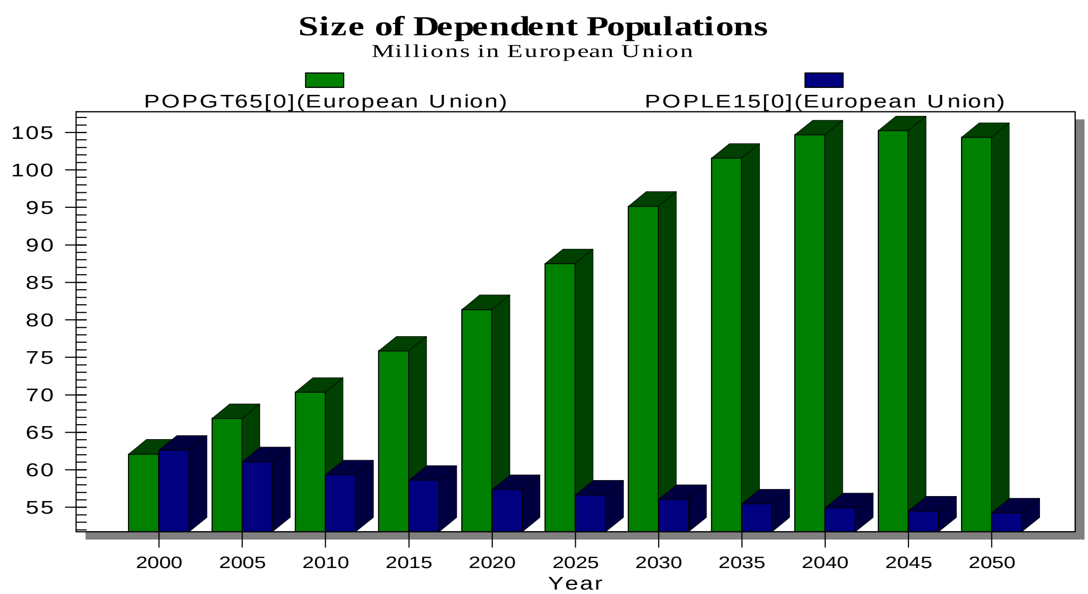


Figure 8.2b Size of OECD Dependent Populations: Over 65 and Under 15

Italy is leading the way within Europe. Within two decades the retired population will be two times as great as the young population. The pattern for Japan is similar.

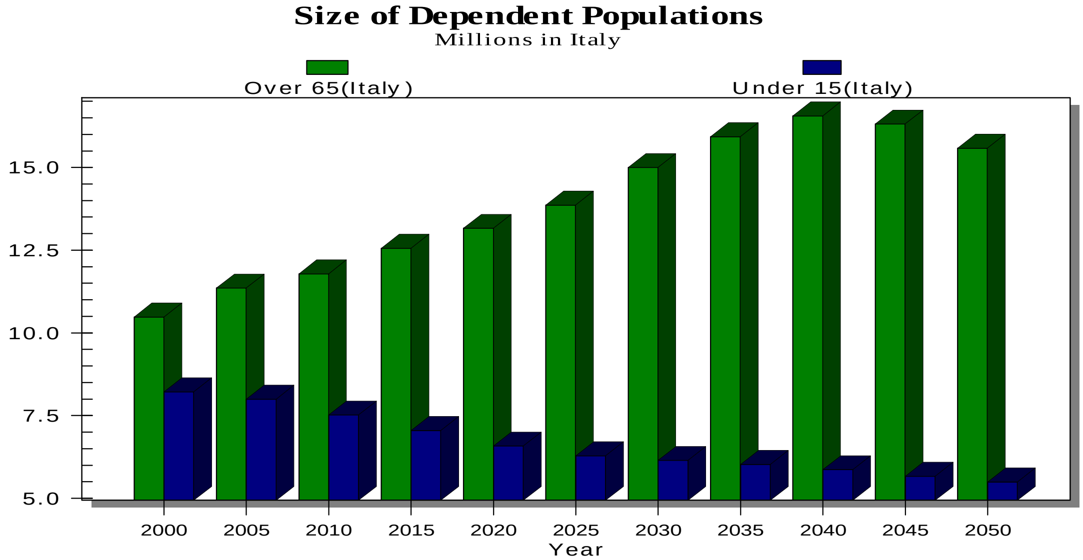


Figure 8.3 Size of Italian Dependent Populations: Over 65 and Under 15

In contrast, the United States is likely to have continued slow growth in the youth population through the first half of the century and it is the relative *growth rate* of the aged population compared to the young dependent population, not its relative *size* that is most striking in the next two decades. Perhaps the most striking thing about the aged dependent population in the U.S. is that, given all of the concern about funding social security in the United States and given the fact that much of that population has considerable independent resources, there is so much (justifiable) concern about funding social security in the United States; taken together, all of that greatly reinforces the concern about funding pensions in the European states profiled above.

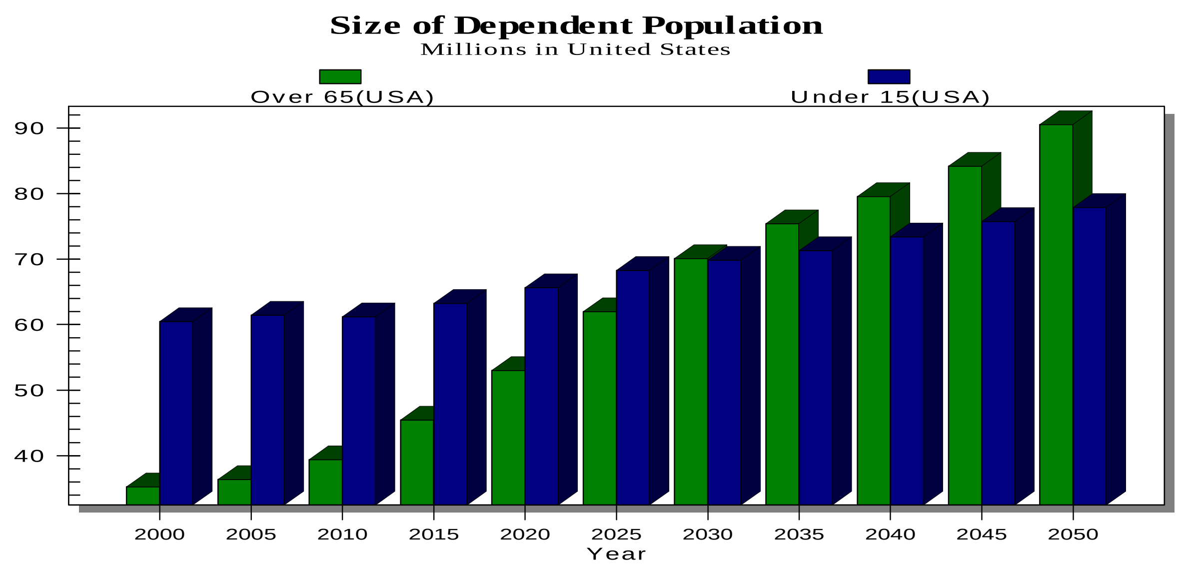


Figure 8.4 Size of U.S. Dependent Populations: Over 65 and Under 15

In non-OECD countries the pattern looks, unsurprisingly given their demographic weight, like that of the world as a whole. Even in developing countries the aged population is growing rapidly. Just as the LDCs of the world increasingly must address simultaneously malnutrition and growing levels of obesity, they increasingly will be tackling the issues of chapter 2 in the demographic transition even before they complete chapter 1.

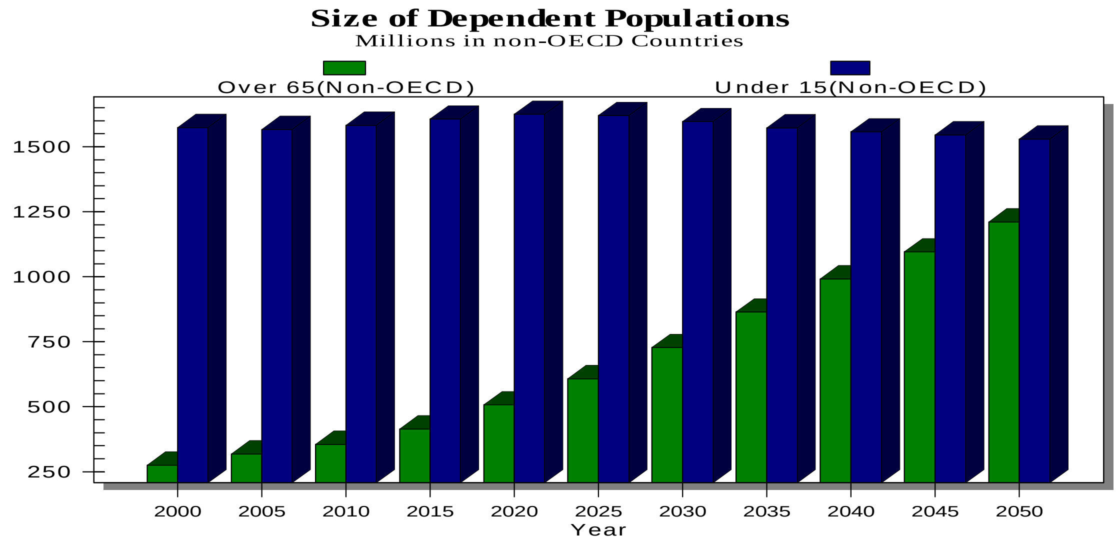


Figure 8.5 Size of LDC Dependent Populations: Over 65 and Under 15

Many discussions about demographic patterns and economic growth potential focus on the number of working-aged individuals per member of dependent population groupings, or the inverse of that, the size of the two dependent populations relative to the number of workers. Looking at the latter for OECD countries, Figure 8.6 shows that the ratio of total dependent population to working-aged population will grow by about 15%, and do so at an accelerating rate after 2010. As shown above, however, it is aged population that is really growing and, for government, that is a more significant fiscal issue.

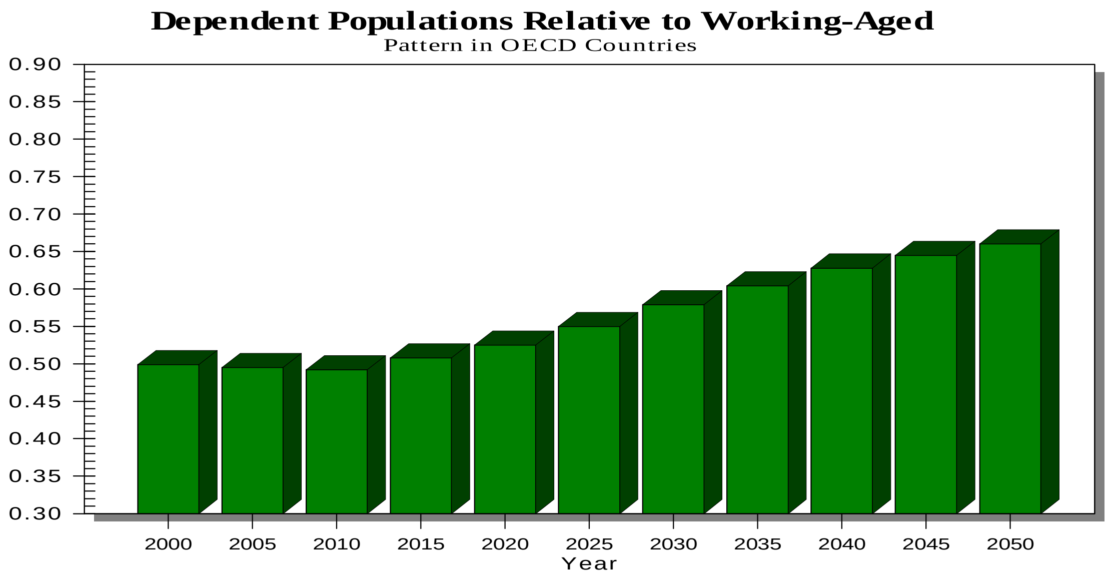


Figure 8.6 Ratio of Total OECD Dependent Population to Working-Aged Population

Because of having had very low birth rates for some time, Italy has had and still has a total proportion of dependent population to working-aged that differs little in aggregate from the OECD total, in spite of a heavier proportion of aged within the dependent population. Strikingly, however, the ratio of total dependent populations to workers will begin to grow rapidly even with continued significant decline in young people. Italy will experience very large increases in the ratio before the middle of the century and especially large rates of increase beginning in about 20 years.

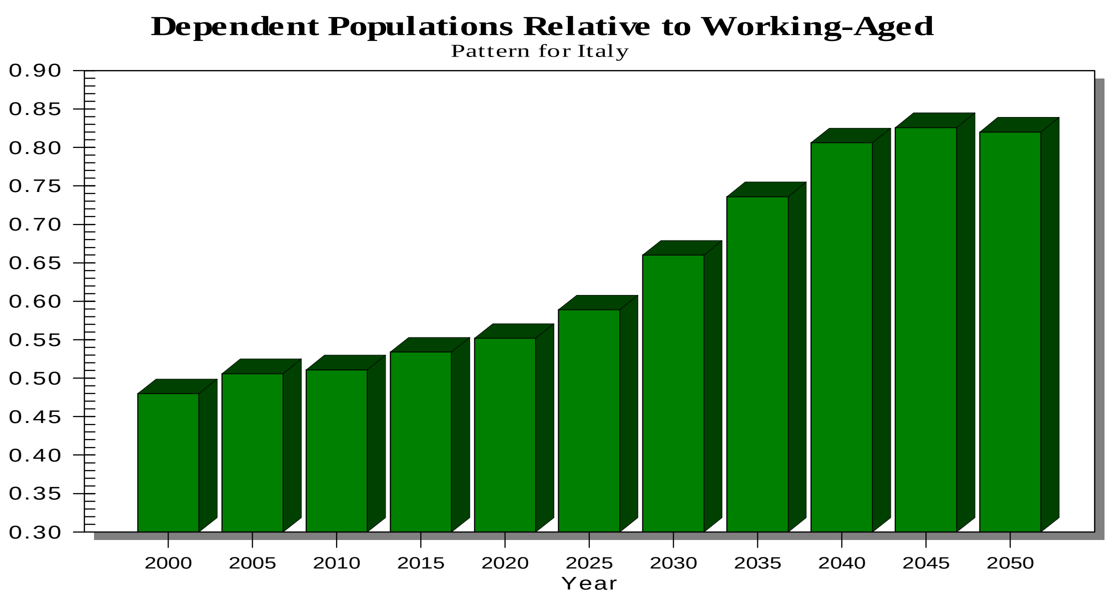


Figure 8.7 Ratio of Total Italian Dependent Population to Working-Aged Population

Some economists have argued that a number of LDCs will actually obtain a fillip to economic growth in the next two decades because of the decreasing size of young dependent populations as fertility continues to drop. On the surface this argument seems plausible, because it correctly assesses the impact of rather stable numbers of young people in non-OECD countries and their decreasing share of total population. It will be interesting, however, to analyze in LDCs whether the shift in character of dependent population to a more aged one will carry costs that offset the lower burden of total dependent population (see Figure 8.8 for the total "burden" ratio). As suggested later in this chapter, the shift from young dependent population to old dependent population actually has the potential for increasing total governmental costs.

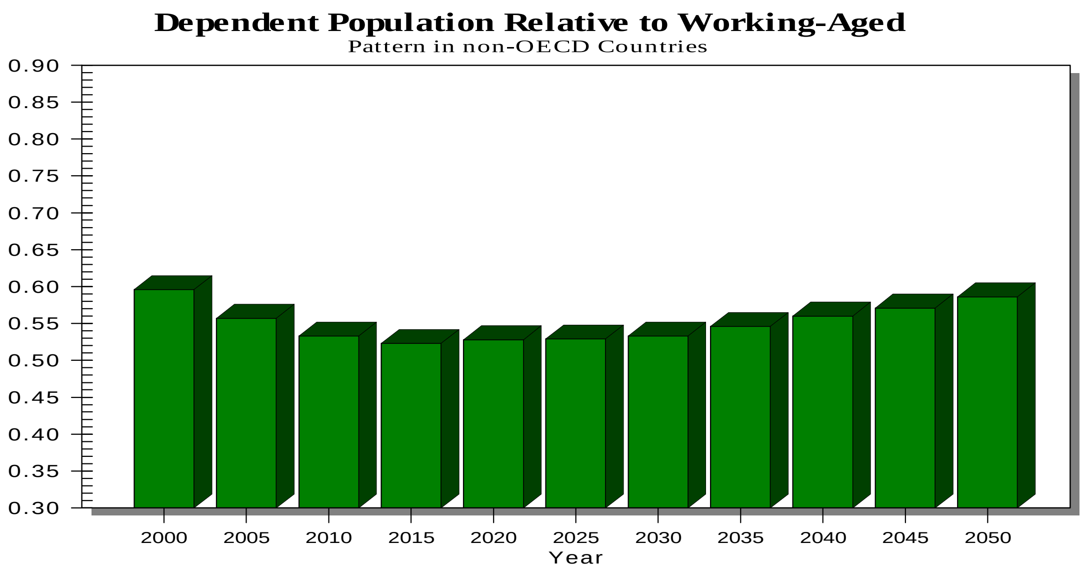


Figure 8.8 Ratio of Total LDC Dependent Population to Working-Aged Population

Another policy issue that many analysts raise concerns the option that more economically developed countries will have to raise migration rates as a way of offsetting the growing burden of pensioners and slower growth in domestic labor forces. Those who migrate do, in fact, tend to be relatively young and on the surface, ignoring brain drain issues, it implies a possible win-win development between developing and more economically-developed countries. There are, of course, many social and cultural issues associated with migration that have already begun to suggest the unlikely character of substantial reliance on migration within much of Europe.

8.1.2 Insights from Social Accounting

Having surveyed the demographic landscape of the issues, analysis can move to the financial side, taking advantage of the economic submodel and SAM structures of IFs. Figure 8.9 is a base case forecast of total global transfers from governments to households. Two aspects of that graph are striking. First, there is the significantly greater magnitude of transfers associated with pensions than of transfers associated with other welfare expenditures (defined here to include unemployment compensation and all other direct transfers not directed explicitly at the elderly). Second, the pension expenditures, already exceeding 8 percent of GDP, may well rise to as much as 15 percent of GDP globally.

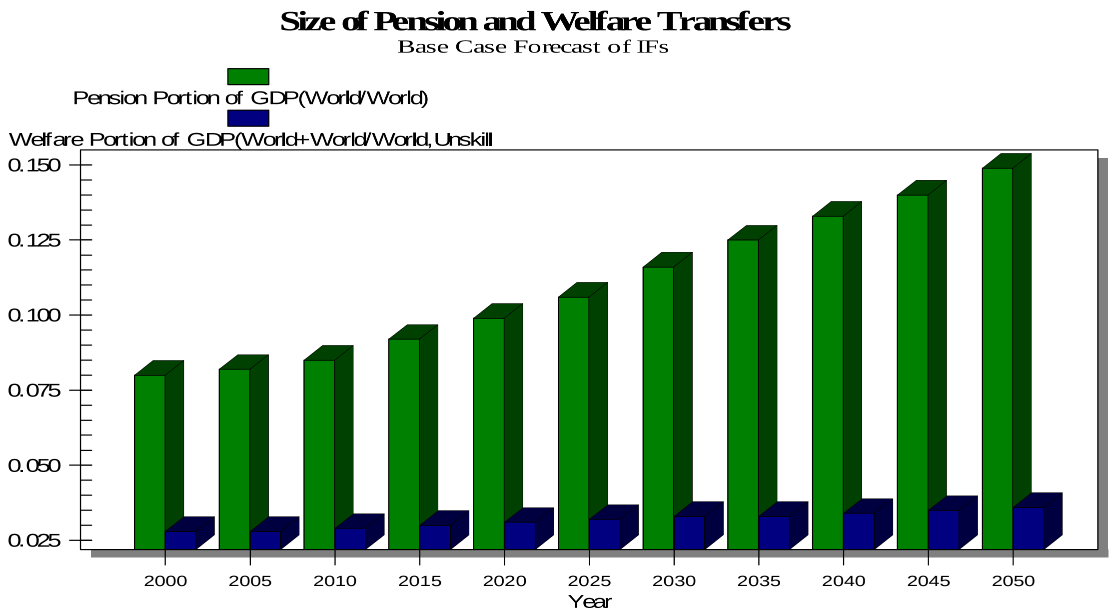


Figure 8.9 Forecast of Global Pension and Welfare Transfers

Making the significance of current and forecast levels for pension expenditures even clearer, Figure 8.10 shows other significant expenditures of government, namely those on health, education, and the military (often collectively labelled as parts of government consumption). There are again several striking elements of that graph. First, the military expenditures, although taking about 2.5% of global GDP now and greater levels in the forecast, are actually smaller than expenditures on health and education. Second, pension transfers as a portion of GDP are already large compared to either health or education spending (education spending gives a rough idea of the costs to central governments of the young dependent population), and promise to become much larger. Third, there appears in the forecast to be some "crowding out" of health and education spending as the expenditures on pensions rise. These two figures are as important to subsequent discussion of the issues of a global safety net and global social protection systems as they are to the discussion of pension systems.

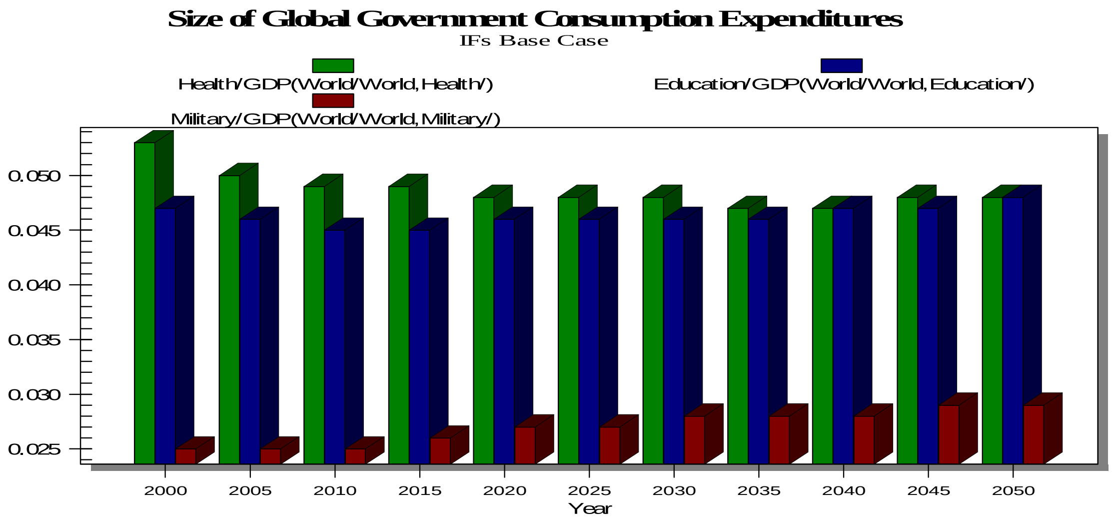


Figure 8.10 Forecast of Governmental Consumption Expenditures on Health, Education, and the Military.

Much further discussion and analysis of the above two graphs would be useful. For instance, the pressure that public pension payments are beginning to put on governments, especially in developed countries, will lead to a variety of changes that help make the above forecasts self-denying. One such change will be the shifting of pension responsibility from governments to individuals; another will be the transformation of pay-as-you-go, defined benefit systems into pre-funded and defined contribution systems.

Nonetheless, the sheer magnitude of increasing pension expenditures is dramatic. Figure 8.11 shows once again that all of the issues will be even more significant in the European Union as a whole and countries like Italy in particular. Italian pension expenditures already take 15% of GDP and could rise well over 20%.

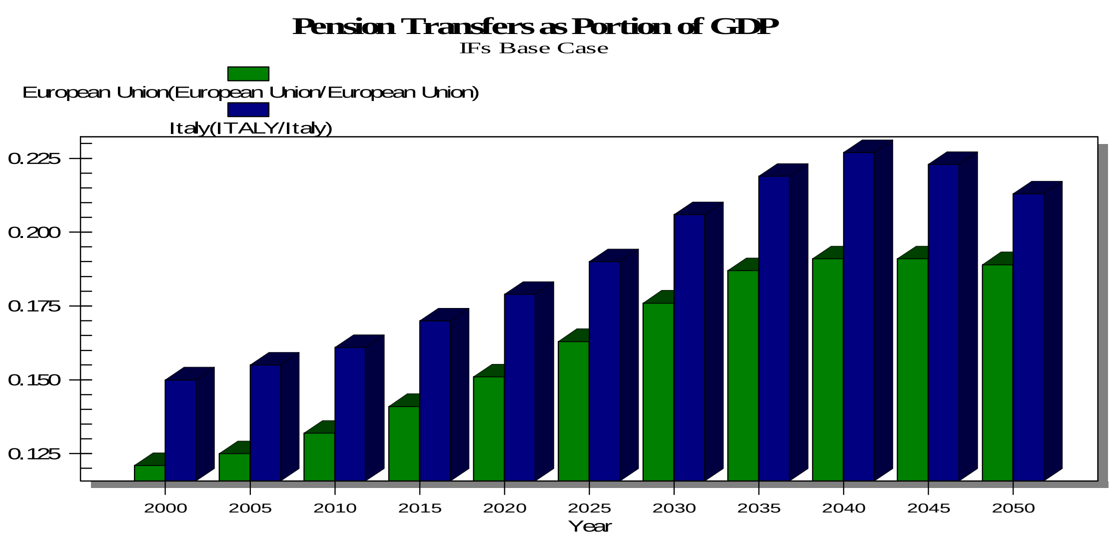


Figure 8.11. Pension Transfers as a Portion of GDP.

Also of real importance, the crowding out issue is of significance not just for OECD countries. Figure 8.12 shows again the base case forecast of pension transfers as a portion of GDP, this time differentiating OECD from non-OECD countries. Rather surprisingly, the rates of transfer grow even more rapidly in the non-OECD countries and rise by mid-century to roughly the same portion of GDP as in the OECD countries.

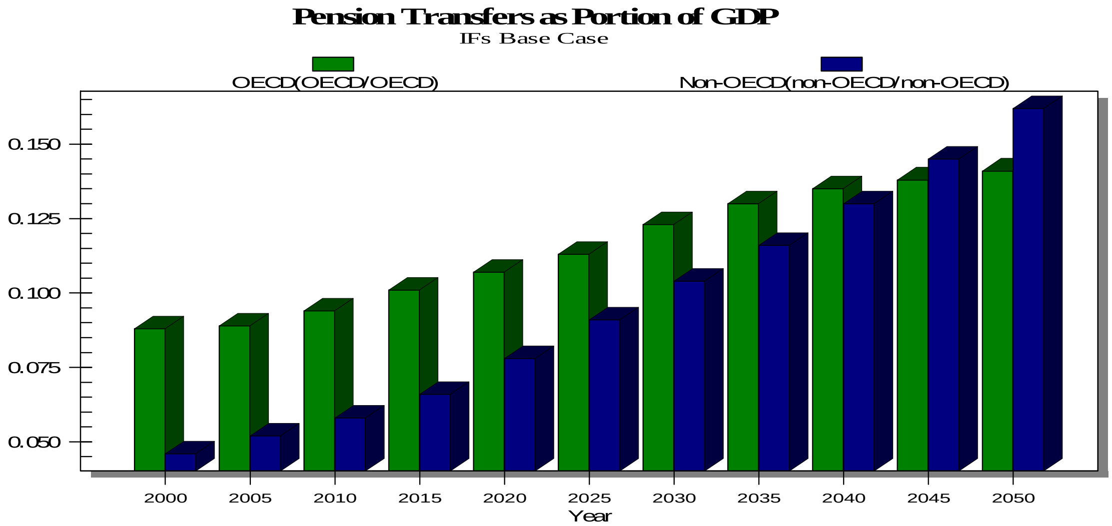


Figure 8.12. Pension Transfers as a Portion of GDP.

How can this be? It is not because the LDCs are likely to become much more generous with pension spending relative to their GDPs/capita. Figure 8.13 shows the ratio of pension spending per individual over 65 to GDP/capita. The IFs forecast of that ratio is probably a bit too high (it should probably be decreasing because many LDCs actually treat their retired government employees relatively more generously than do richer countries), but the ratio is relatively stable.

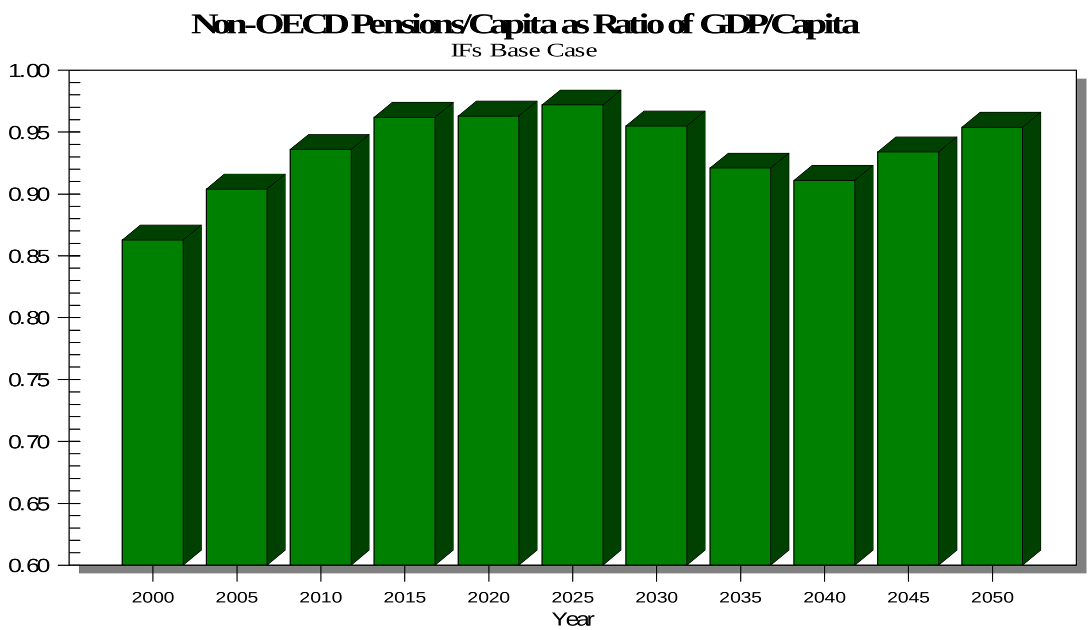


Figure 8.13. Pension Transfers as a Portion of GDP.

Instead, the explanation for rapid increases in the pension expenditures of LDCs goes back to the earlier observation that LDCs are going to begin to experience a key element of the second chapter of the demographic transition (population aging) even before they complete the first chapter (fertility declines commensurate with earlier mortality declines. Figure 8.14 shows how much faster the aged population share is growing in non-OECD countries than even in OECD countries. Ironically, the crowding out effect could be even larger in poorer countries.

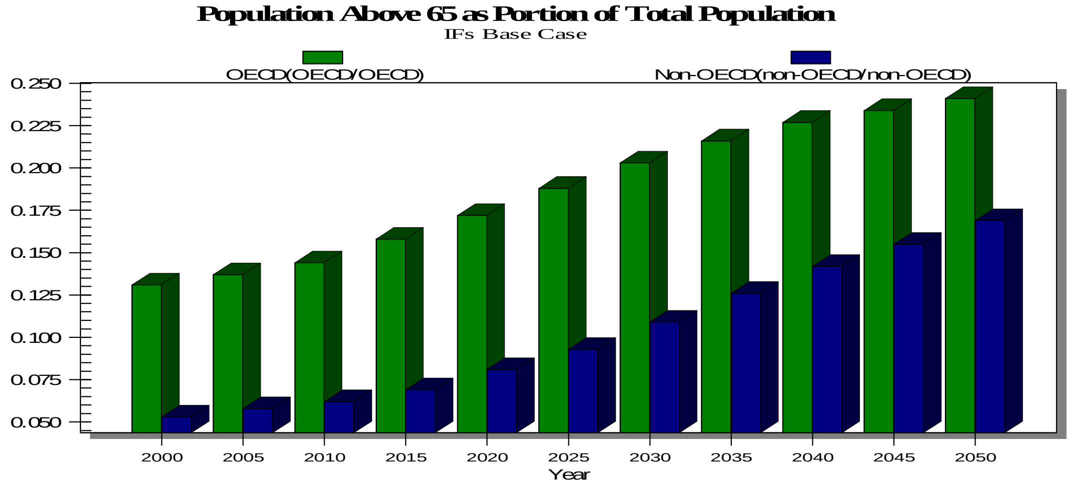


Figure 8.14. Population Above 65 as Fraction of Total Population

Crowding out and hard trade-offs are not restricted to the pattern of government expenditures across categories. The issue of governmental expenditures crowding out other expenditures is a very large (and controversial) one. Most often the argument made is that government expenditures can crowd out investment and slow economic growth. Figure 8.15 shows the base case forecast values of investment as a portion of GDP in the OECD as a whole and Italy specifically. The figure suggests a forecast that seems, and is, incompatible with the expansion of government pension spending and therefore total government spending seen in figures above. The implementation of the SAM in IFs now provides government transfers, even pensions, to households, not to specific age categories within them. And it does not yet represent the life cycle pattern of savings and consumption that makes the elderly much more likely, on average, to consume additional income than are the middle-aged. These enhancements must be made to allow better analysis of possible crowding out of investment.

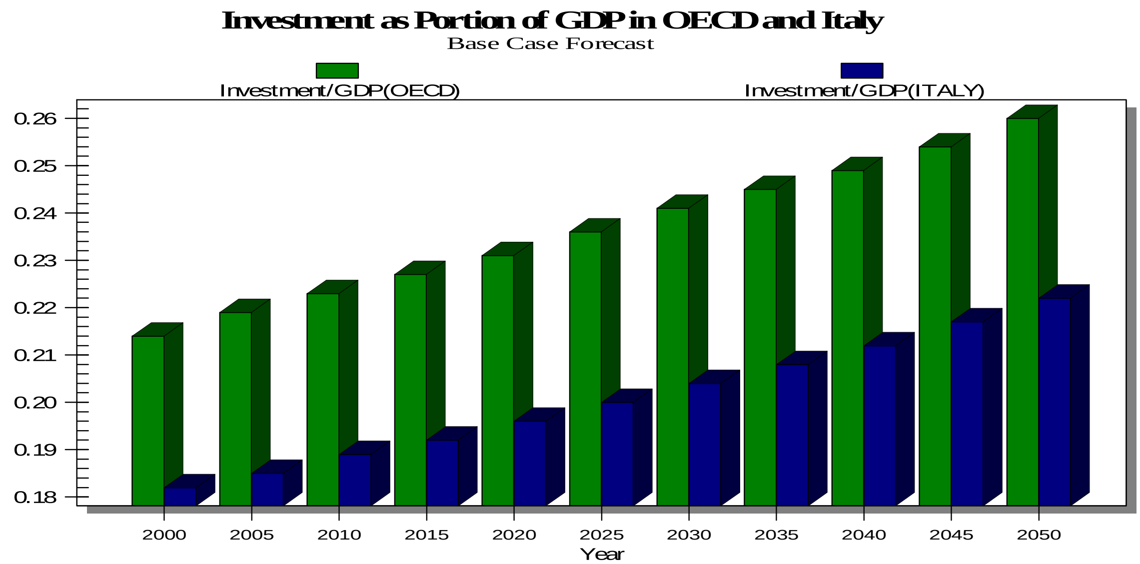


Figure 8.15. Investment as a Portion of GDP

Even in advance of those enhancements to IFs, Figure 8.16 shows the kind of crowding out of other expenditure categories that can occur when government (or investment) increases its direct spending. The base case is showing significant reductions of consumption as a portion of GDP in unskilled households.

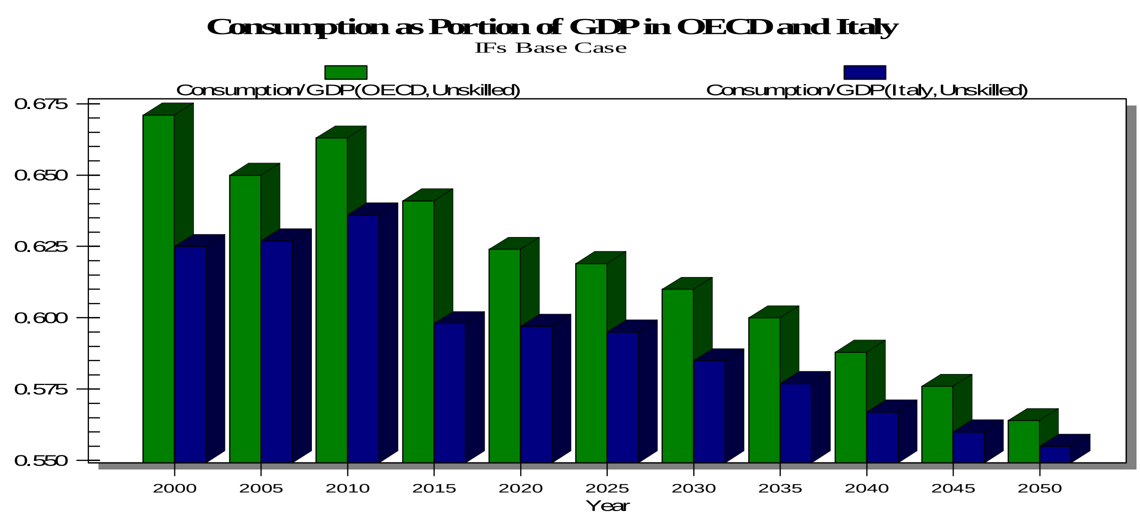


Figure 8.16. Consumption as a Portion of GDP

This very early analysis of the pension issue will be revised and extended, as the SAM representation within IFs is improved. It is, nonetheless, very suggestive. The aging of populations, even in LDCs, is almost certainly going to reshape government expenditure patterns and broader economies in significant ways. Ironically, the impact may by mid-century be as great for LDCs as in richer countries and even, relative to economic capability, greater. We turn next to some equally early analysis that focuses more heavily on developing countries.

8.2 A Global Social Safety Net in Chapter 2 of the Great Economic Transition

Whereas the economically more developed world is approaching a struggle with the growing financial problem around pensions, countries within that world still have in place very strong social safety nets and broader social protection systems. In contrast, most developing countries have yet to put in place any significant safety net. And, as we have seen, it is only a matter of another 3-4 decades before they will be facing some of the same demographic pressures that are just beginning to challenge much richer countries. Is it truly reasonable to expect that the world can meet Millennium Summit Goals and many other statements of intent to educate populations, provide adequate water and sanitation, and support urgent needs of individuals who now struggle and often fail to survive on daily incomes of $1 or $2 or less?

There are some signs of hope and some reason to believe that it is possible. The probability of continued global economic growth is a strong reason for hope, in and of itself. And there is hope especially in the potential for solid growth in LDCs.

Just as large gaps arose between fertility and mortality rates in the great demographic transition of the last 200 years, beginning with European countries and spreading around the world, large gaps also arose over that period between the GDPs/capita of European and other countries. More specifically, the GDPs/capita of the European countries and the settler states of Europeans (notably the United States, Canada, Australia, and New Zealand) moved from about twice those of the rest of the world to levels of 15-20 times those of the rest of the world at market exchange rates (to about 6-8 times the rest of the world at purchasing power parity).

And just as we are moving into chapter 2 of the demographic transition, there is evidence that we are moving into chapter 2 of the economic transition. Although it is controversial, there is good reason to believe that the aggregate size of the economic gap between North and South, in ratio terms, has begun to decrease. The substantial drops in fertility in the South and the resultant window of opportunity with respect to dependent-aged population in the South (see again Figure 8.8) and the processes of technology transfer with globalization are forces that may well drive substantial narrowing of the gap in the first half of the 21st century. It must also be recognized, however, that HIV/AIDS, environmental degradation, and other factors could also retard such narrowing or even lead to further widening. And it must be understood that the narrowing of North-South gaps is a reflection in particular of growth in Asia, while Africa continues to slide further behind the rest of the world.

The base case of IFs, to be discussed below, is built on forecasts of continued basic economic progress in developing countries. Chapter 6 will expand our horizons with potential scenarios that are less optimistic (and others that are more optimistic).

8.2.1 The Context of the Social Protection/Safety Net Issue

In the base case of International Futures, economic growth per capita continues in both richer (largely OECD) and poorer countries (largely non-OECD). Figure 8.17 shows the base case forecast of growth in GDP per capita (using purchasing power parity) for both OECD and non-OECD countries.

The rates of economic growth in the forecast are actually a little conservative relative to rates in the last 40 years of the 20th century. Specifically, global GDP during that 40 year period increased by a factor of about 4.1, while GDP per capita at PPP increased by 2.36. The rates that underlie Figure 8.17 are such that, in the 40 years from 2000 through 2040, the global GDP will increase by a factor of 3.2 and GDP per capita at PPP will increase by 2.08.

Slower demographic growth in more developed countries is one reason for a more conservative total growth forecast, and are further a reason for anticipating a relative shift in growth towards the South. Between 1960 and 2000, the GDP per capita at PPP increased for OECD countries by a factor of 2.84; the forecast is for an increase in the next forty years by only a factor of 1.67.[9] In non-OECD countries the historic increase was a factor of 2.74; the forecast is for an increase of 2.91 in the next forty years. Again, this is by no means the only possible demographic-economic scenario that could serve as a base line for analysis of a global safety net. It is, however, both a credible one and one that scenarios with IFs can easily change.

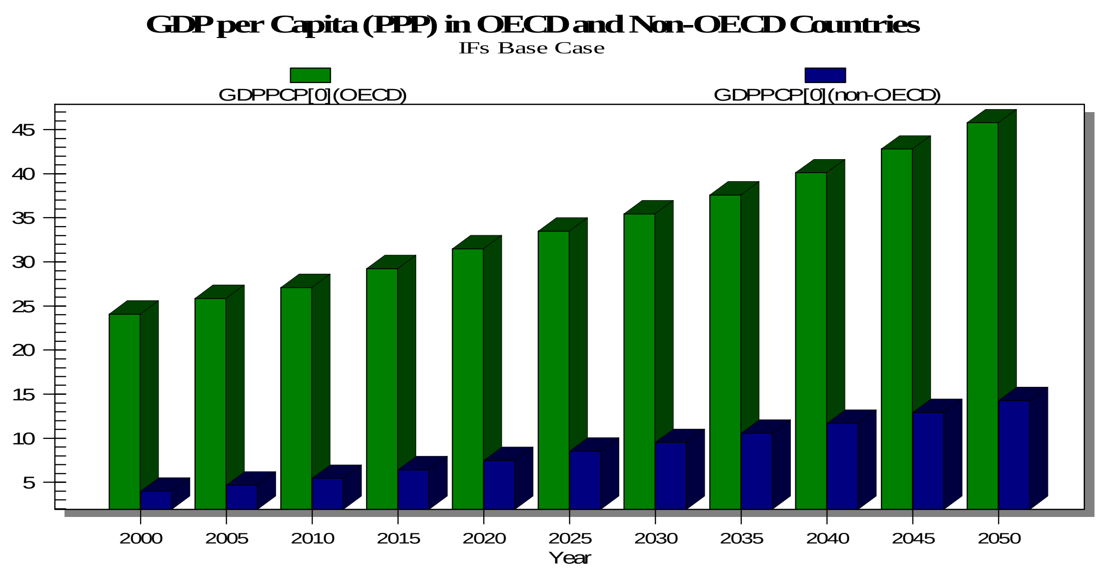


Figure 8.17 Patterns of Global Growth in GDP per Capita (PPP)

[9] Angus Maddison (1995 and 2001) has provided some of the very best analysis of historic growth. He refers to the age that includes the 1960s as the "Golden Age," and in addition to pointing out the unparalleled character of rapid growth during it, is skeptical about the ability of the world to match it in coming decades.

The slightly unorthodox character of the base case scenario is more evident in Figure 8.18, which shows the ratio of GDP per capita in OECD and non-OECD countries. That ratio in the IFs base case is narrowing, as indicated above.

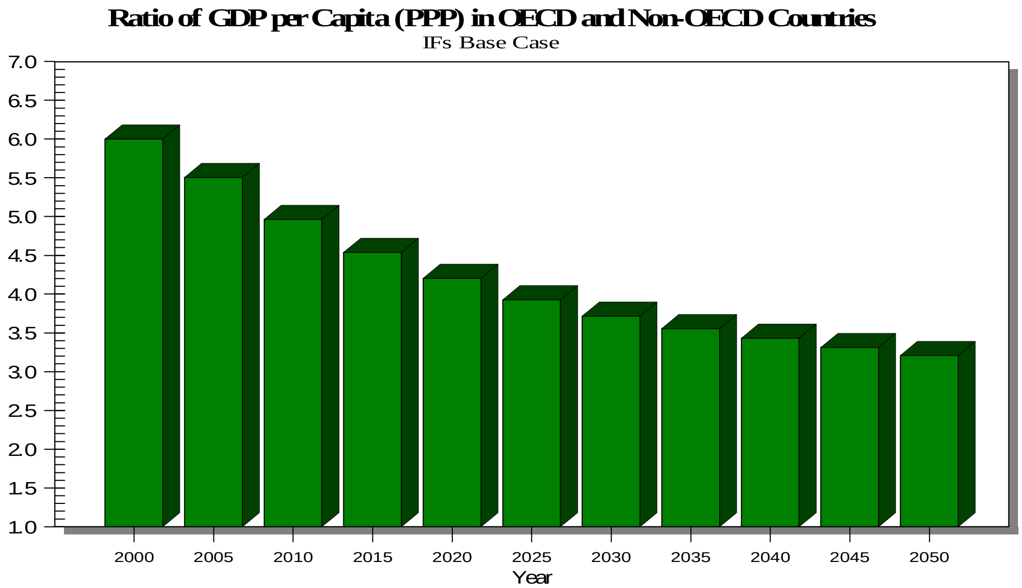


Figure 8.18 The Global Ratio of North/South GDP per Capita (PPP)

Figure 8.19 shows some of the historic basis for anticipating such narrowing of the North/South gap in ratio terms. Whereas that gap increased steadily throughout essentially the entire era since the early industrial revolution, in seems to have stabilized in the 1970s and 1980s and actually to have decreased in the 1990s in spite of the "New Economy" of the more developed countries.

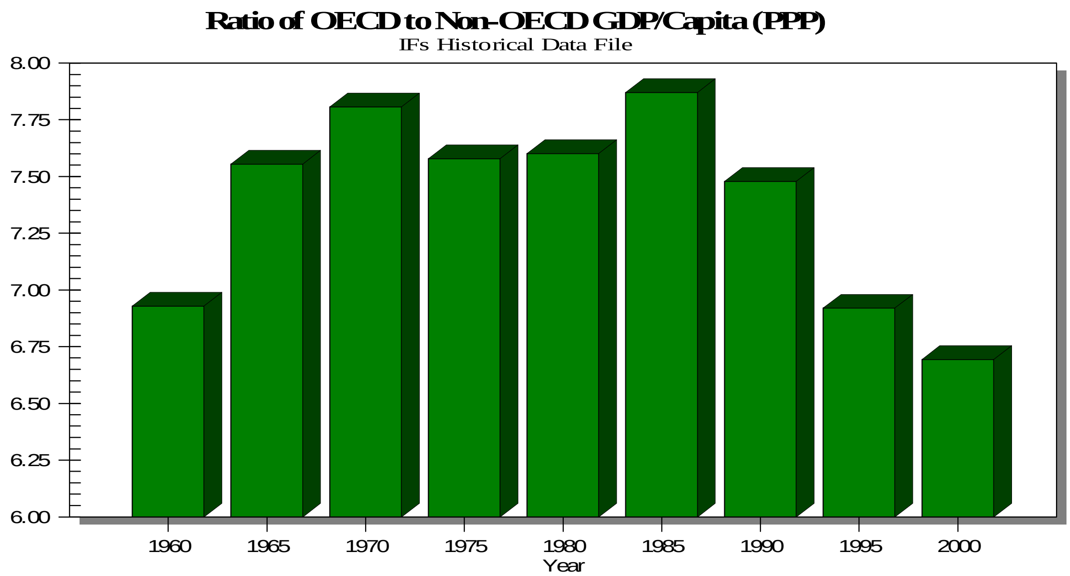


Figure 8.19 Historic Change in the Global Ratio of North/South GDP per Capita (PPP)

It is important to understand also, however, that the reason for the historic decrease in ratio of North-South GDP per capita was an economic break-out by countries in the Asia-Pacific region, including the giants of India and China in recent years. In contrast, there has actually been a decline in the aggregate GDP per capita of sub-Saharan African states in the last two decades.

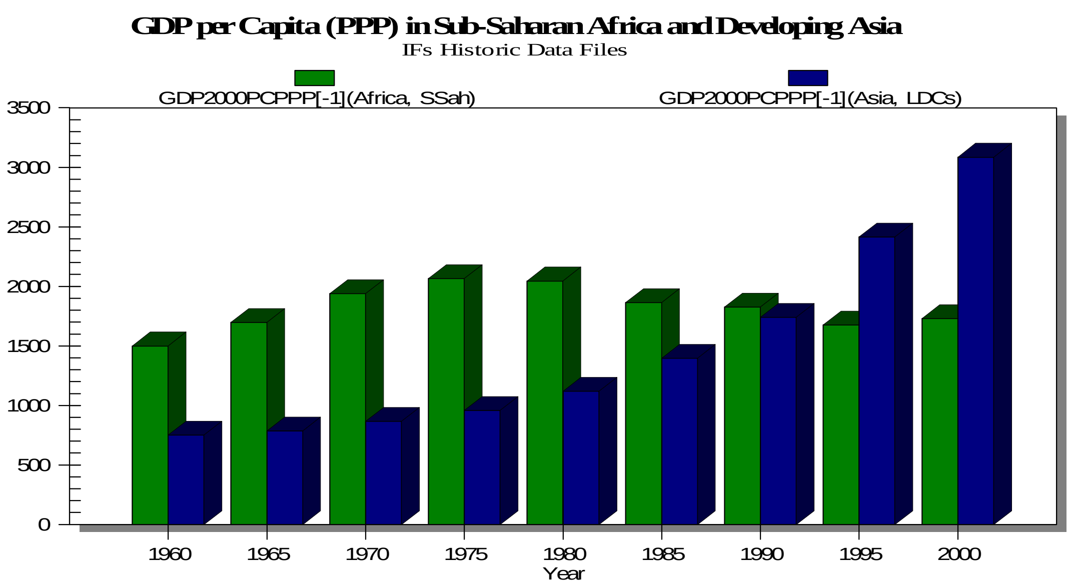


Figure 8.20 Historic Change in the GDP per Capita (PPP) in the South

As we further address issues around a global safety net, it will be very important to maintain a focus on the great differences in potential for implementation of a safety net that Figure 8.20 conveys. The very large and growing burden of HIV/AIDS in Africa is another element of that differentiation in prospects and potential (although Eberstadt 2002, building on CIA analysis, has forecast that the burden will increasingly spread to China and India in the Asia-Pacific region, as well as to Russia). Figure 8.21 conveys the current base case forecast in IFs of HIV cases in Africa and the Middle East, a forecast that obviously and arbitrarily introduces growing progress against the disease in the 10-20 year time horizon.

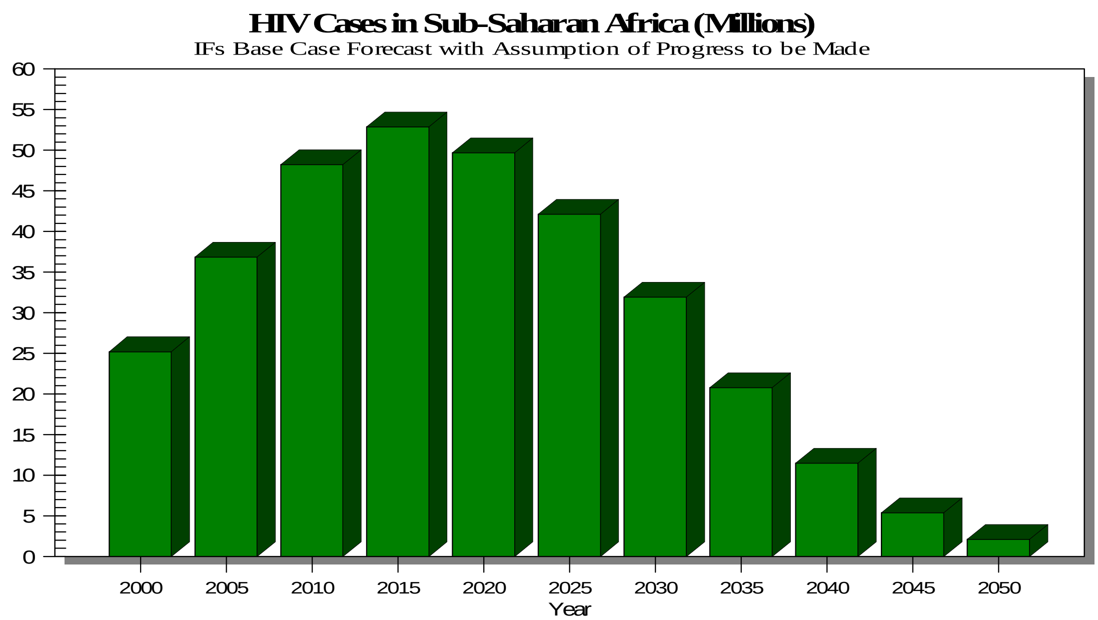


Figure 8.21 A Forecast of HIV Cases in Africa and the Middle East

In short, the demographic-economic context for extending a global safety net to the developing world is considerably more complex and uncertain than is the more predominantly demographic context for meeting pension demands in the developed world (as discussed earlier). Scenarios, to which Chapter 6 returns, will be as important in this analysis as are policy interventions.

8.2.2 <u>Insights from Social Accounting</u>

Even before turning to scenario analysis, however, it is useful to take a quick look at some of the kinds of capability that a SAM-based analysis can bring to the investigation. Figure 8.22 directs our attention to the unskilled households in the Sub-Saharan Africa and Developing Asia regions. It is often pointed out that more than a billion people around the world live on incomes of less than $1/day (UNDP 2002:18). That is sometimes hard to see in country-level data that show relatively few countries with GDP per capita of less than $500 (at PPP). The differences in income between skilled and unskilled households in LDCs are, of course great and the SAM's differentiation of households into skilled and unskilled subsets lets us look specifically at the most impoverished. When we focus our attention on unskilled households (using GDP per capita at exchange rates), we see that even after the remarkable economic success of recent years, the average incomes of Asian-Pacific unskilled households are approximately $1/day (the numerical average value for those unskilled households in

2000 is actually $383, across countries with a total population of 3 billion) and the household incomes of the unskilled in sub-Saharan Africa are even lower. Further, the forecast for growth in unskilled household income in sub-Saharan Africa, given the decline of the last 20 years, may be optimistic.

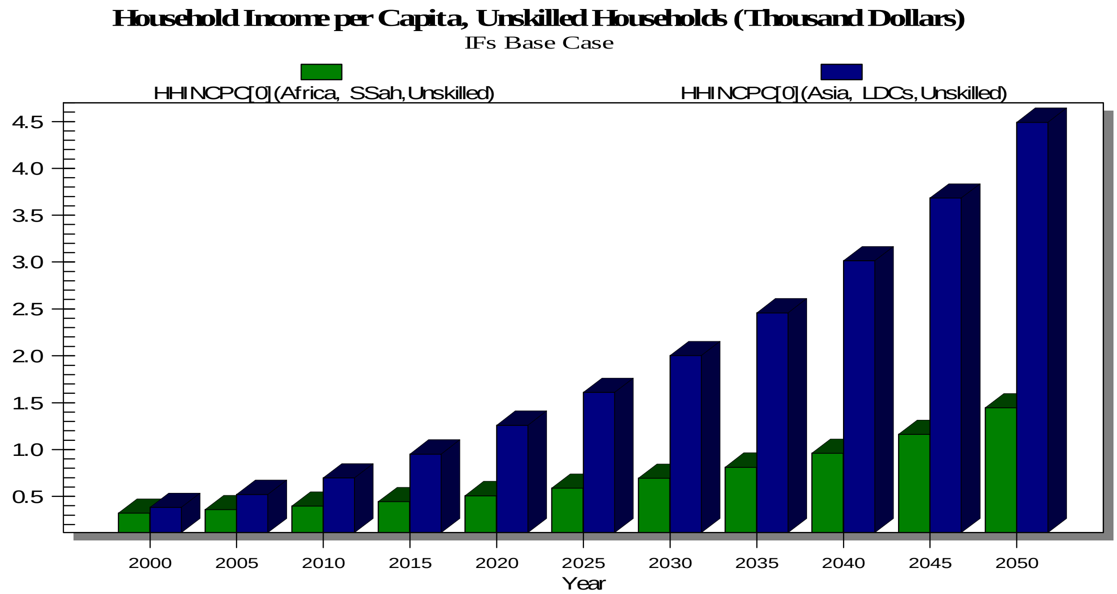


Figure 8.22 Unskilled Household Income per Capita in LDCs

Nor are base case forecasts of per capita welfare transfers to unskilled households of any significant magnitude. Figure 8.23 shows that they are tiny and, moreover, suggests that that they might actually decrease in the future, a result that is likely again a crowding out effect.

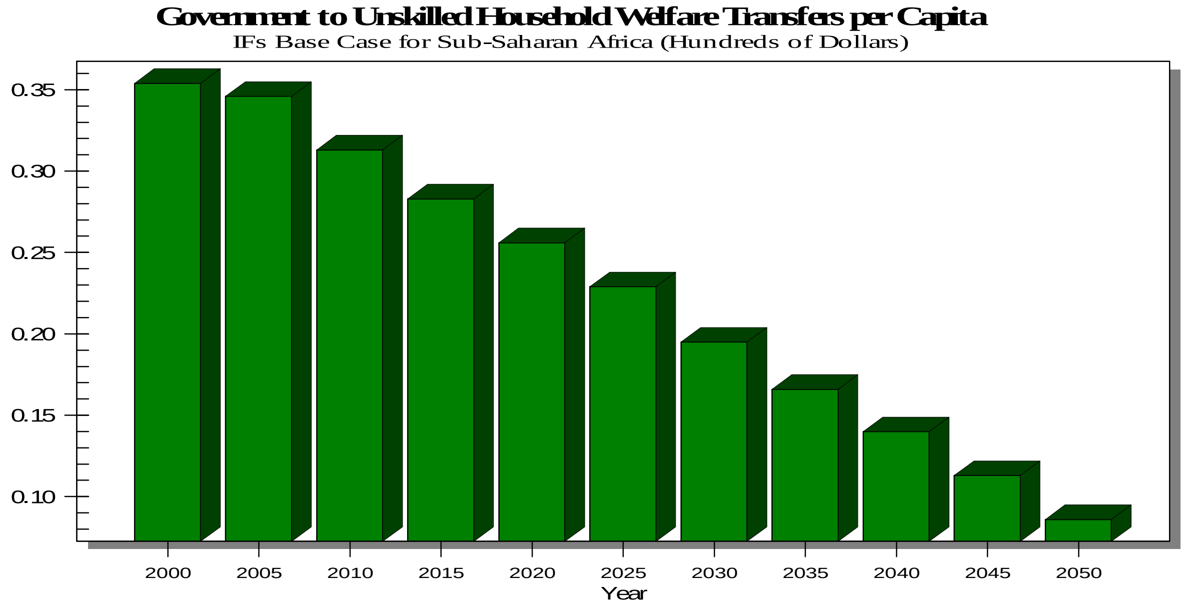


Figure 8.23 Government Welfare Transfers per Capita in Africa and the Middle East

Figure 8.24 presents a somewhat more optimistic picture, however, because it returns our attention from welfare transfers to total transfers (including pension funds). As we saw earlier, the growing old populations of developing countries (not, obviously, those in the most severely-AIDs stricken countries) will be requiring, and may receive greater assistance. Figure 8.24 suggests that, in the current base case of IFs, pensioners do much better than broader populations, an initial set of assumptions that probably should be challenged.

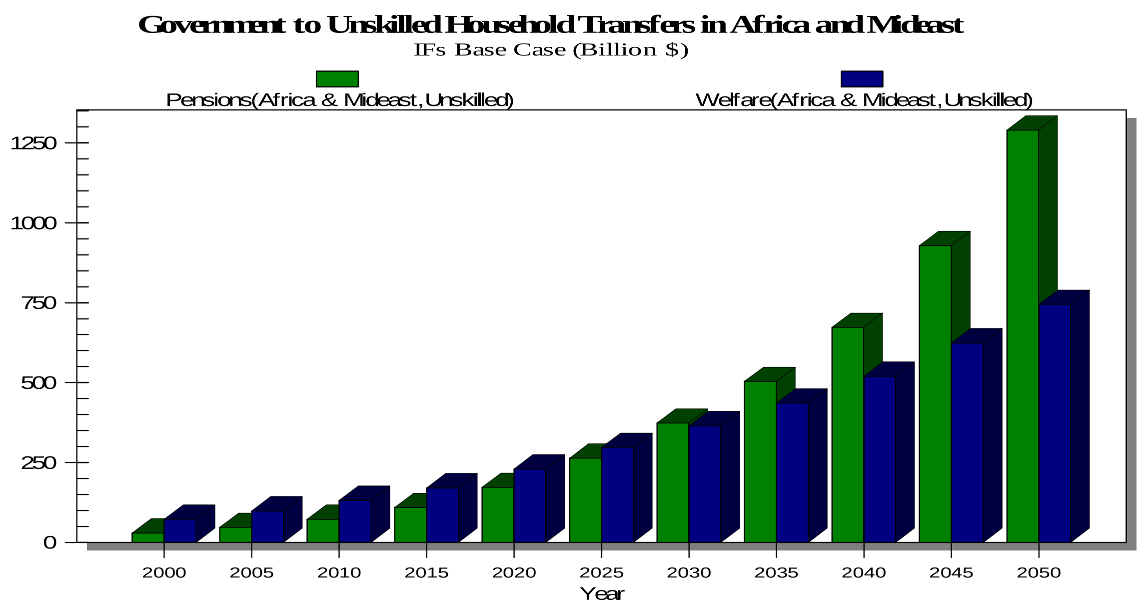


Figure 8.24 Total Government Transfers in Africa and the Middle East

The purposes of this chapter have been (1) to convey some of the context of meeting social needs of rich and poor countries in the first half of the 21^{st} century and (2) to provide some very early insight into how analysis with IFs, including a SAM structure, can unfold. Although the initial analysis here is subject to very considerable extension and refinement, it already conveys the magnitude of the challenges in attempting to create safety nets in LDCs. Alternative scenarios, to which we turn now, will further explicate both the range of uncertainty that exists around those challenges and the policy leverage that social actors have with respect to them.

9. Scenarios

This chapter will be drafted over the coming months. It will have several components:

1. An identification of key uncertainties that affect/frame analysis of social support for human development. It has already been suggested above that demographic and economic uncertainties may be the most critical for the analysis (unless otherwise indicated, there are scenario handles in IFs for structuring alternative scenarios on the following key uncertainties):

    - In demographics these will include demographic patterns of extension in longevity (major extensions would dramatically change the entire pension issue); changes in fertility rate for developed countries from currently low and below replacement levels (will those rates rise again to replacement rates or sink further?); progress against HIV/AIDS (or lack of it and possibly even other plagues).
    - In economics these will include rates of technological change and the diffusion of it (have we shifted long-term productivity rates up by 1% with ICT as some claim or not as others argue?); and the extent of globalization (could the backlash forces reverse it? – globalization is not as fully represented as it could be in IFs, because we have trade, but not FDI and portfolio financial flows).
    - Other issue areas treated within IFs might also be useful in developing framing scenarios. For instance, in energy the rate of progress towards less expensive renewable energy technology could have affects that propagate across the economic system, as could environmental issues such as carbon emissions and water availability (water availability is represented in quite basic fashion in IFs).

2. An identification of primary policy leverage points that affect/frame analysis of social change. It has already been suggested above that a number of these will relate to the activities of the actors/institutions represented within the SAM. Again, unless otherwise noted, levers exist in the IFs interface for:

    - Governmental actors play key roles with decisions around total spending and revenue levels; allocation of spending between direct consumption/expenditures (such as health care, education, and the military), on one hand, and transfer payments, on the other; and allocations of expenditures within categories (e.g. between health care and education, between primary and tertiary education, or between pensions and more general social welfare).
    - Households play important roles with respect to the trade-off between current consumption and savings/future consumption

- Firms could play important roles, most prominently also on trade-offs between re-investment and profit distribution; that capability is not yet present in IFs.
- External states plan key roles with decisions on foreign aid, loans, debt forgiveness (debt forgiveness is not yet a policy handle in IFs).

Key uncertainties and primary policy leverage points sometimes overlap or interact (changes in governmental fiscal policy, for instance investment in R&D, could affect productivity growth rates).

We will develop a set of bright and dark scenarios for general framing and explore the sensitivity of outcomes to policy changes over a range of interacting alternatives. In the process of doing this, we will clearly keep in mind goals, such as the basic goal of enhancing HDI levels, or the broader set of the Millennium Summit goals.[10] We will also keep in mind the possibility that some darker scenarios should emerge from policy wrong-turns (consider, for example, the failure by Mbeki to address HIV/AIDS in South Africa).

[10] The ability to link up IFs to the CARS system of RAND will greatly facilitate this scenario and outcomes exploration.

10. Next Steps

Some of the next steps have been identified throughout this draft, but many have not. A number of these activities can proceed in parallel:

- Continued refinement of the SAM presentation within IFs. Most of the project effort over the last 8 months has been devoted to creating and extending the SAM., and much of what was initially planned has been accomplished. There is, however, always room for enhancement. Much of the future effort will be directed at improving representation of agents and agency:
    - Endogenizing life-cycle consumption patterns for households so that the propensity to consume on pensions is appropriately represented as considerably higher than that of income accruing to younger populations
    - Expansion of the number of household types, possibly with empirical help from either the World Value Survey or the World Bank.
    - Pass through of firm investment to households should be revisited. Firm earnings retention should be tied ultimately to (a) depreciation of K plus (b) new investment.
- Developing and exploring a range of scenarios (high priority). In that process, there will inevitably be discoveries about model behavior that lead to refinements and extensions of the system.

In addition, there are some elements of enhancement that may be less obvious from the above text. One of the most important is a clearer representation of the dynamics of labor supply and demand and their interaction, using the unskilled/skilled labor categories. Some of the dynamics for labor demand are already present in the relationships developed from GTAP data between labor payments by sector and GDP per capita. A basis for representing labor supply by household type exists in the educational model of IFs and the differentiation between primary, secondary, and tertiary educated populations; in fact, an initial representation of changing labor supply has been introduced. The preliminary representation of labor supply using this formulation suggests that skilled labor supply grows too rapidly relative to labor demand unless it is assumed that significantly decreasing portions of those with secondary education are skilled in more developed than in less developed economies. The reasons for refining these labor demand and supply representations include better tying of decisions about education to broader development, but also include the potential of having a labor market representation that provides some insights into the potential for increasing or decreasing inequality within countries.

This paper is a living document that will grow and change substantially over coming months. Feedback is always appreciated.

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