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GUIDE TO SCENARIO ANALYSIS IN INTERNATIONAL FUTURES (IFs)

(Based on IFs 8.25)

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Introduction

The purpose of this document is to facilitate the development of scenarios with the International Futures (IFs) system. This document supplements the IFs Training Manual. That manual provides a general introduction to IFs and assistance with the use of the interface (e.g., how do I create a graphic?). In turn, the broader Help system of IFs supplements this manual. It provides detailed information on the structure of IFs, including the underlying equations in the model (e.g., what does the economic production function look like?).

This document should help users understand the leverage points that are available to change parameters (and in a few cases even equations) and create alternative scenarios relative to the Base Case scenario of IFs (e.g., how do I decrease fertility rates or increase agricultural production?). It proceeds across the modules of IFs, such as demographic, economic, energy, health, and infrastructure, to (1) identify some of the key variables that you might want to influence to build scenarios and (2) the parameters that you will want to manipulate to affect your variables of interest. The Training Manual will help you actually make the parameter changes in the computer program and the Help system will facilitate your understanding of the structures, equations and algorithms that constitute the model. We begin by introducing the types of parameters within IFs and then proceed to a discussion of variables and parameters within each of the IFs modules.

A Note on Parameter Names

In this manual we will provide the internal computer program names of variables and parameters, as well as their descriptions. Those names are especially important for use of the Self-Managed Display form, which provides model users with complete access to all variables and parameters in the system. Most model use, however, employs the Scenario Tree form to build scenarios and the Flexible Display form to show scenario-specific forecasts, and both of those forms rely primarily on natural language descriptions of variables and parameters. To match the names provided here with the options in those forms, you can use the Search feature from the menu. The Training Manual describes how to use features such as the Flexible Display form to see computed forecast variables in natural language. And it also describes how to use the Scenario Tree form to access parameters in something close to natural language. Nonetheless, it helps very much in the use of those features and the model generally to know the actual variable and parameter names.

Types of Parameters in IFs

Equations in IFs have the general form of a dependent or computed variable, as a function of one or more driving or independent variables. *Variables*, like population and GDP, are the dynamic elements of forecasts in which you are ultimately interested. For instance, total fertility rate or TFR (the number of children a woman has in her lifetime) is a function of GDP per capita at purchasing power parity (**GDPPCP**), education of adults 15 or more years of age (**EDYRSAG15**), the use of contraception within a country (**CONTRUSE**), and the level of infant mortality (**INFMORT**). In the most general terms the equation is

$$TFR \ = \ F\left(GDPPCP, EDYRSAG15, CONTRUSE, INFMORT\right)$$

Parameters of several kinds can alter the details of such a relationship. That is, *parameters* are numbers (also represented by names in IFs), that help specify the exact relationship between independent and dependent variables in equations or other formulations (including logical procedures called algorithms). For instance, the model may contain different parameters that tell us how much TFR rises or falls per unit change in GDP per capita,

education levels, contraception use, and infant mortality;[1] and it also allows to set bounds on the lower and/or upper values of TFR over the long run (obviously TFR should never go negative and probably we will not even want it to go, at least for a long time, to a very low level such as an average of 0.5 children per woman). Some of these parameters are more technical than others in the sense that they may significantly affect the overall stability of the model if users are not very careful with the magnitude or direction of the changes they make; we will focus heavily in this manual on parameters that are easiest to interpret and modify.

In many cases, we are more interested in using a parameter to make a direct change to a variable, rather than indirectly affecting a variable like TFR through one of its drivers. We often refer to this as the "brute force" method of changing a variable, and this can be done by multiplying the entire result of a basic equation like that above by a number, adding something to that result, or simply over-riding the result with an exogenously (externally) specified series of values. In the case of TFR we use the multiplier approach, which is described below. The strengths of this approach should be obvious: it preserves model stability, and makes the model more accessible for users. However, the weakness is that in many instances it is more realistic to affect one of the drivers of TFR rather than TFR directly.

Beyond multipliers, there are many other types of parameters that IFs uses, although we are forced to abandon TFR to provide examples. For instance, a switch parameter may turn on or off a particular formulation in preference to another. A target may specify a value towards which we want a variable to move gradually (we would need to specify both the target level and the years of convergence to it).

Overall, key parameter types are:

1. **Equation Result Parameters**. Most users will use these parameter types far more often than any other. The three types are:

a. **Multipliers**. This most common of all parameter types in scenario analysis comes into play after an equation has been calculated. They multiply the result by the value of the parameter. The default value, i.e. the value for which the parameter has no effect and to which multipliers almost invariably are set in the Base Case, is 1.0. These parameters are usually denoted with the suffix -**m** at the end of the parameter name**.**

b. **Additive factors**. Like multipliers, these change the results after an equation computation, but add to the result rather than multiplying. The default value is normally 0.0. These are usually denoted with the suffix -**add** at the end of the parameter name.

c. **Exogenous Specification**. Sometimes these parameters override the computation of an equation. In other cases, they are actually substitutes for having an equation; that is, they are actually equivalent to specifying the values of a variable over time for which the model has no equation. This typically means establishing a new exogenous series. They typically will have the name of the variable that they over-ride within their own name.

2. **Targets**. Especially for the purposes of policy analysis, we often want to force the result of an equation toward a particular value over time (e.g. to achieve the elimination of indoor use of solid fuels). Target

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[1] Because the nature of the equation or formulation will vary (sometimes a driving variable is linearly linked to the dependent variable, sometimes the equation uses a logarithmic, exponential, or other formulation), the coefficients in the equation cannot invariably or even regularly be interpreted as units of change linked to units of change. You may need to explore the Help system and specific equations to fully understand the relationship. This is one of the key reasons we very often turn to the multipliers and additive factors explained in the next paragraph.

parameters are generally paired, one for the target level and one for the number of years to reach the target (from the initial year of the model forecast, 2010). Targets have different types:

a. **Absolute targets**. In this case the target value and year define the absolute value the variable should move toward and the number of years after the first model year over which the goal should be achieved. Together they determine a path in which the value for the variable moves quite directly[2] from the value in first year to the target value in the target year. **Trgtval** and **trgtyr** are the parameter suffixes used for this parameter type. The first of these changes the target itself, and the second alters the number of years to the target. The default value of *trgtyr parameters should normally be 10 years, but in some cases it is 0, meaning that users must set the number of years to target as well as the target value in order to use these parameters.

b. **Relative (standard error) targets**. In this case, the target value and year define a relative value towards which the variable should move and the number of years that will pass before the target is reached. The relative value is defined as the number of standard errors above or below the "predicted" value of the variable of interest (a prediction usually based on the country's GDP per capita). Target values less than 0 set the target below the typical or predicted (as indicated by cross-sectional estimations) value of the variable. Target values above 0 set the target above the predicted value. As with the absolute targets, the value calculated using relative targeting is compared to the default value estimated in the model. The computed value then gradually moves from the normal or default-equation based value to the target value. If, however, the computed value already is at or beyond the target (that could be above or below depending on whether the target is above or below the default or predicted value), the model will not move it toward the target. Two different parameter suffixes direct relative targeting: **setar** and **seyrtar**. The first of these changes the target itself and the second alters the number of years to the target. The default value of the *seyrtar parameters varies based on the module and even variable. Governance parameters are set to a default of 10 years from the year of model initialization, while infrastructure parameters are set to a default of 20 years. These defaults mean that users do not have to change ***seyrtar** as well as ***setar** in order to build standard error target scenarios. Changing ***setar** should be enough.

3. **Rates of change**. Some parameters specify an annual percentage rate of change. Unfortunately, IFs does not consistently use percentage rates (5 percent per year) versus proportional rates (0.05 increase rate per year, which is equivalent to 5 percent), so the user should be attentive to definitions. There are multiple suffixes that may apply to these, including -**r** (changes in the rate) and -**gr** (changes the rate of change, growth or decline).

4. **Limits**. As indicated for the TFR example, long-term national rates are unlikely to fall and stay below a minimum value. Limits can be minimum or maximum values. These are typically denoted by the suffixes -**min**, -**max**, or -**lim.**

5. **Switches.** These turn off and on elements in the model. These most often affect linkages between modules, but can also change relationships within modules. They are typically denoted by the suffix -**sw**.

6. **Other parameters** in equations and algorithms. Equations within IFs can become quite complicated. The parameter types discussed to this point provide the easiest control over them for most model users. Relatively few users will proceed further with parameters, and to do so will typically require attention to

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[2] The movement normally will be linear, except that it is possible to set moving targets that create non-linear progression patterns. In some cases, the model explicitly uses non-linear convergence; e.g. to accelerate movement in early years and then to slow it as the target is approached.

the specific nature of the equation (e.g. whether independent variables are related to dependent ones via linear, logarithmic, exponential or other relationship forms). That is, one would normally need to understand the model via the Help system or other project documentation in order to use them meaningfully and without causing substantial risk of bad model behavior. The sections of this manual will provide very little information about these technical parameters.

a. **Elasticities**: These are relatively common within IFs and specify the percentage change in the dependent variable associated with a percentage change in the independent variable. They are typically prefixed **el-** or **elas-**.

b. Equilibration **control parameters.** IFs balances supply and demand for goods and services via prices, savings and investment with interest rates, and so on. These processes typically use an algorithmic controller system that responds to both the magnitude of imbalance or disequilibrium and the direction and extent of its change over time (see the Help system descriptions of the model). Although they are not typical elasticities, the two parameters that control each such process usually have the prefix **el-** and the suffixes **-1** or **-2**. Parameters ending with **1** relate to disequilibrium magnitude; and parameters end with **2** relate to the direction of change.

c. Other coefficients in equations. Beyond elasticities, many other forms of parameter can manipulate an equation. When analysts in many fields think of parameters, this is what they mean. In IFs, most users will use them quite rarely because, in the absence of knowledge concerning equation forms and reasonable ranges, the parameters often have little transparent meaning—experts in a field may use them more often. Many analysts think of such parameters as having a constant value over time, and some are unchangeable over time in IFs. IFs allows almost all, however, to be entered as time series and vary with great flexibility across time. Some can be changed for each country and/or sub-dimensions of the associated variable, such as energy types, but others can only be changed globally.

d. Equation forms. Although most users will change parameters using the Scenario Tree (see again the Training Manual), the IFs model has made it possible over time to change an increasing number of functions directly (both bivariate and multivariate ones). The advantage this confers is the ability to alter the nature of the formulation (e.g. going from linear to logarithmic) and even, to a very limited degree, the independent or driver variables in the equation. Although some module discussions will occasionally suggest this option, most users will not avail themselves of it. Users who wish to make such changes can do so via the Change Selected Functions options, which can be accessed from the Scenario Analysis Menu on the main page.

7. **Initial conditions** for endogenous variables and convergence of initial discrepancies.

a. **Initial conditions** are not, strictly speaking, true parameters, but should reflect data. Yet some users will believe that they have data superior to that in IFs, and the system allows the user to change most initial conditions. After the first year, the model will compute subsequent values internally (endogenously). Initial conditions don't have a suffix; their names are, in fact, those of the variable itself (e.g., **POP** for population).

b. **Convergence speed** of initial condition-based discrepancies to forecasting functions. Because initial conditions taken from empirical data often vary from the values that are computed in the estimated equation used for forecasting, the model protects the empirically based initial condition by computing shift factors that represent that initial discrepancy (they can be additive or multiplicative). For many variables, values rooted in initial conditions in the first model year should converge to the value of the estimated equation over time; convergence parameters

control the speed of such convergence. Most model users will never change the convergence speed. These are denoted by the suffixes **-cf** or **-conv**.

In the use of all parameters, especially those other than equation result parameters, users will often be uncertain how much it is reasonable to move them—as are often even the model developers. The Scenario Tree form provides some support for judgments on this by indicating high and low alternatives to that of that Base Case. This manual will sometimes provide some additional information.

Manipulating Parameters in IFs

You will typically manipulate parameters to create *scenarios* or internally coherent stories about the future. You may create scenarios because you wish to represent and explore the possible impact of policy interventions. Or your stories may represent views of the dynamics of global systems alternative to that in the IFs Base Case scenario. Most of the time, you will be interested in tracking the possible futures of selected variables having particular interest to you. The following sections, each covering a module of the IFs system, begin by identifying some of the variables of potentially greatest interest to you. They then provide suggestions on which parameters are likely to be of most useful in building alternative scenarios for those variables. Each section includes tables listing the most effective parameters with which to target certain outcomes. While these suggestions are intended to help you start to think about which parameters you might use to build your scenarios, it is essential that you consider seriously what the policy-based, empirical-knowledge-rooted, or theoretically informed foundations are for your changes.

Keys to Successfully Modifying Parameters in IFs

- Test all parameter changes individually before building combinations, in order to be able to identify which parameters are having specific impacts.
- After changing a parameter value and running a scenario, check the impact on the most proximate or closely related variables (identified in the tables of each module section), before checking the secondary impacts of your selected parameter on more distally related variables.
- Tie parameter changes to policy options, empirical knowledge, or theoretical insight identified in literature.
- Bear in mind the relevant geographical level at which a parameter operates; some parameters function directly at a global level (e.g., global migration rates), while others will be most relevant at the regional, or national level.
- Some parameters are only effective when used in combination with one another (such as target values and years to reach a target).
- Some parameters cancel one another out; for example, **trgtval** and **setar** parameters cannot be used together except under very limited circumstances that we attempt to note in the subsequent text.
- In many cases, variables affected by certain parameters have natural maximums (e.g. 100 percent) or minimums (e.g. fertility rate), so that changes to the parameters affecting them, where countries may already be approaching such a limit, will not have a significant impact.
- The IFs systems contains many equilibrating processes, such as those around prices; interventions meant to affect one side of such an equilibration (such as efforts to reduce energy demand) may have offsetting effects (such as lower prices for energy and resultant demand increase) that make it harder than you expect to push the system in the desired direction; real-world policy makers often face such difficulties and may need to push harder than anticipated.

Prepackaged Scenarios

A number of alternative scenarios come prepackaged with the model. To access them, select Scenario Analysis from the main menu, and then the option labeled Quick Scenario Analysis with Tree. Once in the scenario display, select Add Scenario Component to view all of the. sce (scenario) files that are stored on your computer normally at the path C:/Users/Public/IFs/Scenario. Exploring several simple interventions contained in the folder structure should give users an overview of some of the leverage points they may wish to use in each module.

Modules

Demographic Module

Variables of Interest

Variable	Description
POP	Total population
POPLE15	Population, age 15 or less
POP15TO65	Population, age 15 to 65
POPGT65	Population, greater than 65
POPPREWORK	Population, pre-working years
POPWORKING	Population, working years
POPRETIRED	Population, retired
YTHBULGE	% of the population between 15 and 29
POPMEDAGE	Population, median age
LAB	Labor force size
BIRTHS	Births
DEATHS	Deaths
MIGRANTS	Net migration (inward)
CBR	Crude birth rate
CDR	Crude death rate
TFR	Total fertility rate
CONTRUSE	Contraceptive usage
LIFEXP	Life expectancy
MIGRATE	Net migration rate (inward)

The IFs demographic module breaks country populations down into 21 five-year age groups, each one subdivided by gender. This allows the model to create an age-sex cohort structure that responds to changes in the three fundamental drivers of population: fertility, mortality, and migration. Births are calculated as a function of each country's fertility distribution and age distribution. As children are born, they enter the lowest band of the age-sex structure, the layer representing people aged 0 through 5. Each country's population growth is reduced by deaths at each age level; like births, deaths are calculated as a function of the mortality distribution and the age distribution. Finally, migration patterns either add to, or subtract from, each country's population, depending on the balance of immigration and emigration[3]. Each of the three proximate drivers of population is influenced by deeper social processes: births are a product of fertility patterns; deaths are linked to life expectancy; and net migrants are determined by an overall global migration rate.

Total population is represented in millions of people via **POP**, but users may also choose to explore the age structure within society. Three variables break population down into broad age groups: **POPLE15**, people age 15 or younger, **POP15TO65**, people age 15 to age 65, and **POPGT65**, people older than age 65. Three additional variables provide a similar disaggregation of population: **POPPREWORK**, **POPWORKING**, **POPRETIRED**—as the names suggest, they measure the number of people who have yet to enter their working years, the number of people currently in their working years, and the number of people who have completed their working years. The years comprising an adult's working life may vary from country to country, depending on education systems and retirement ages. Users can explore additional population characteristics via the variables **YTHBULGE**, the percent of all adults (15 and older) between the ages 15 and 29; **POPMEDAGE**, the median age of a country's population; and **LAB**, the size of the labor force, recorded in millions of people. For any country, the complete age and sex breakdown is available under the Specialized Displays for Issues option under the Display sub-menu. From the Specialized Displays menu, select Population by Age and Sex, and click the button labeled Show Numbers. This will bring up detailed population figures for any of the countries in the IFs system. To view a population pyramid display, toggle the Distribution Type setting on the menu bar.

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[3] In IFs, the age distribution of migrants is controlled by an internal vector across age categories, not available for manipulation through the model's front-end.

The three immediate drivers of population change—births, deaths and migration—are captured in the model as flows. Every year babies are born (**BIRTHS**), people die (**DEATHS**) and people leave countries to live elsewhere (**MIGRANTS**). These processes alter the stock of population in countries, regions and the world as a whole. The speed at which a population will grow or decline, and the attendant shift in a population's age structure, depend on crude birth rates (**CBR**) and crude death rates (**CDR**)—the number of births and deaths per 1,000 people.

Each of the immediate drivers is linked to deeper determinants of population. For instance, fertility rates are responsive to income, education and infant mortality rates, offering points of access elsewhere in the model. Total Fertility Rate (**TFR**) is a variable that is essential to our understanding of populations' reproductive behavior. **TFR** is, essentially, the number of children the average woman in a country can expect to have over the course of her lifetime. In order for the overall population size to remain roughly stable, **TFR** must meet the replacement rate for that country. For developed countries this is approximately 2.1 children per woman, but the figure may be higher in countries with high mortality rates and is lower in many. While **TFR** largely determines future population growth, it is not the only behavioral variable of note: **CONTRUSE** captures the percent of fertile women who routinely use some method of contraception.

For a complete discussion of mortality see the [Health module](#), where deaths are computed. They are responsive to deep or distal factors such as income, education and technological advance, as well as to more proximate ones such as levels of undernutrition and smoking. A key indicator for the population model, linked to deaths, is **LIFEXP**, or life expectancy, which provides a measure of the median life expectancy of a newborn in a particular year given the current mortality distribution. Although life expectancy can be calculated for any age, IFs focuses on life expectancy at birth. This variable is key to the functioning of the IFs system because many of the parameters that affect mortality do so by changing life expectancy.

The final proximate driver of population growth is migration. **MIGRANTS** measures net migrants in raw figures, reported in millions of people; but this variable is determined by **MIGRATE**, the net migration rate, reported as percent of the total population. The basic forecasts of migration in IFs are one of the very few variables that are exogenous. Nonetheless, there is parametric control of it.

The demographic module features an array of parameters that allow users to create alternative demographic scenarios by exploring uncertainty surrounding fertility, mortality and migration, as well as the years making up people's working lives.

Parameters to Affect Fertility

Parameter	Variable of Interest	Description	Type
tfrm	TFR, CBR	Total fertility multiplier	Multiplier
contrusm	CONTRUSE	Contraceptive use multiplier	Multiplier
eltfrcon	TFR	Elasticity of total fertility rate to contraception use	Elasticity
tfrmin	TFR	Long term TFR convergence value	Limit

The single most powerful way for users to modify fertility rates is to manipulate **tfrm**, a parameter that directly alters the total fertility rate within a country or region. This parameter serves as a multiplier on the fertility rate calculated by the model—a 20% increase or decrease in the value of the parameter will result in a similar magnitude of change in the value of the associated variable, **TFR**. Because it is a brute force multiplier, users should justify their modifications to the parameter. When used thoughtfully, **tfrm** can be a powerful tool for scenario analysis. It can be used to model the impact of fertility control initiatives that extend beyond simple contraceptive use. An example would be the implementation of a program to offer public seminars on the benefits of having fewer children, which could lower the fertility rate even when overall contraceptive usage rates are low. Health care programs for women are a major contributor to fertility decline.

Users can also directly change the percentage of the population that uses contraceptives via **contrusm**, a parameter that indirectly affects the total fertility rate via **CONTRUSE**. As this is a multiplier, it works the same way as **tfrm**. It can be used to model the impact of an increase in the availability of family planning education, a campaign to promote the use of condoms, or any other intervention that would likely increase (or decrease) the percentage of a population using contraceptives. Additionally, the parameter **eltfrcon** allows users to control the elasticity of total fertility to contraceptive use. For example, a weaker relationship between the two variables might be justified if the contraceptive methods in use in a country or region are widely known to have high failure rates.

When creating alternative scenarios that span long time horizons, users may wish to modify fertility assumptions built into the demographic module. As countries grow richer and reach higher levels of educational attainment, total fertility rates tend to decrease. However, in forecast years, a minimum value prevents countries from dipping too far below replacement rate. As a default setting, the minimum parameter, **tfrmin**, is set to 1.9. Thus, in the Base Case, **TFR** in highly developed countries will converge to just below 2 children per woman. By increasing or decreasing the parameter, users can experiment with different long-term fertility patterns.

Parameters to Affect Mortality

Parameter	Variable of Interest	Description	Type
mortm	DEATHS	Mortality multiplier (not cause specific)	Multiplier
hlmortm	DEATHS	Mortality multiplier by cause	Multiplier

The health module write-up includes a full description of the drivers of mortality in the IFs system, and explains how to manipulate each one. However, one parameter affecting mortality, **mortm**, is worth discussing separately.

This parameter functions similarly to the **hlmortm** parameter available in the health module, but does not disaggregate by cause of death. Similar to **tfrm**, **mortm** can be used to model the impact of events that have broad impacts across the population, such as the end of an armed conflict or the implications of a plague. Usually however, if a user is building a scenario analyzing health trends, using the **hlmortm** multiplier will be more useful because it disaggregates mortality on the basis of cause. Because morbidity rates in IFs are linked normally to mortality rates, these parameters will affect them also.

Parameters to Affect Migration

Parameter	Variable of Interest	Description	Type
wmigrm	MIGRATE, MIGRANTS	World migration rate multiplier	Multiplier
migrater	MIGRATE, MIGRANTS	Net migration rate (inward) as a percent of total population	Rate of change
migrateinm	MIGRANTS, MIGRANTSIN	Inward migration rate multiplier	Multiplier
migrateoutm	MIGRANTS, MIGRANTSOUT	Outward migration rate multiplier	Multiplier

Users interested in modifying migration patterns should bear in mind that migrant flows are subject to an accounting system that keeps the global number of net migrants equal to zero. In other words, a person leaving one country will be accounted for when they enter another country. Changing the world migration rate, **wmigrm**, is the easiest way to affect migration patterns in IFs. Altering this parameter will allow users to increase the overall rate at which migration occurs at a global level, enabling users to simulate large scale increases (or decreases) in migration generated by, say, reductions in visa fees, or the opening of borders as is the case in the EU's Schengen area. The parameter **migrater**, on the other hand, allows users to affect the rate of migration into individual countries or regions (values can range from positive, indicating net inward migration, to negative, indicating net outward migration). Alternatively, **migrateinm** and **migrateoutm** can also be used to change inmigration and outmigration rates for a country or region.

Parameters to Affect Working Age

Parameter	Variable of Interest	Description	Type
workageentry	POPPREWORK, POPWORKING	Working age determinant/ Age of common entry into work force	Exogenous specification
workageretire	POPWORKING, POPRETIRED	Retirement age determinant/ Age of normal retirement	Exogenous specification
workageretirendpctuse	WORKAGERETIREND	Percent of needed retirement age to deal with aging	Exogenous specification
workageretiresv	CPCTND	Age of retirement to compute savings rate	Exogenous specification

In addition to manipulating the rate at which populations grow, users can experiment with the effects of changing a country's working age, something that will be fiscally important in many countries as populations age. The variables **POPPREWORK**, **POPWORKING** and **POPRETIRE** map the typical age structure of a country or region's work force. Two parameters, **workageentry** and **workageretire**, control the age at which a person is considered eligible for work and the age at which a person is eligible for retirement. Changes in the workforce's age

configuration link forward to economic production via the size of the labor force (**LAB**). Raising or lowering the retirement age will additionally affect government finances via the size of population of retirement age and the level of pension support provided to households (**GOVHHPENT**).

Prepackaged Scenarios

Installation of IFs includes high and low population-framing scenarios. Originally created for the poverty volume of the Pardee Center's Potential Patterns of Human Progress (PPHP) series, the two files are located in the Framing Scenarios folder under Population. Both scenarios feature the direct total fertility rate multiplier. **Tfrm** in the high fertility scenario is set to 1.5 globally. In the low fertility scenario, **tfrm** is set to .6 in non-OECD nations, and the limit parameter **tfrmin** is set to 1.6 globally. Although the two scenarios only feature a few interventions, the effects of such a large change in human reproductive behavior would have significant forward linkages throughout each of the model's systems.

Four of the prepackaged scenarios located in the folder Interventions and Agent Behavior contain additional examples of the demographic module's parameters: Non OECD Contraception Use Slowed, Non OECD Contraception Use Accelerated, World Migration High, and World Migration Low. The pair of scenarios focusing on contraceptive usage rates both utilize **contrusm**. In the accelerated scenario, the multiplier takes the value 1.2 in non-OECD nations; and the value 0.8 in the slowed scenario for all non-OECD nations. The two alternate migration scenarios similarly feature interventions on a single parameter: the global migration multiplier **wmigrm**. In the high scenario the parameter takes on a value of 2, doubling global migration flows; and in the low scenarios flows are halved, with **wmigrm** declining to a value of 0.5.

Health Module

Variables of Interest

The primary variables of interest in the IFs health module are those that pertain to mortality and morbidity due to a variety of causes. **LIFEXP** and **CDR**, discussed in the [population module](#), provide basic measures of population health. **DEATHCAT** provides a measure of the number of deaths (in thousands) due to different categories of mortality. IFs can display health variables in the following categories of disease: Other Communicable Disease, Malignant Neoplasm, Cardiovascular, Digestive, Respiratory, Other Non-Communicable Diseases, Unintentional Injuries, Intentional Injuries, Diabetes, AIDs, Diarrhea, Malaria, Respiratory Infections, and Mental Health. Using the Flexible Display form, it is also possible to see many of these variables in the rolled-up categories of Communicable Disease, Non-Communicable Disease, and Injuries or Accidents. Because different health conditions affect age cohorts differentially, the above

Variable Name	Description
LIFEXP/LIFEXPHLM	Life Expectancy
CDR	Crude Death Rate
DEATHCAT	Deaths by Mortality Type
HLYLL	Years of Life Lost
HLYLLWORK	Years of Working Life Lost
HLYLD	Years Lived with Disability
HLDALY	Disability Adjusted Life Years Lost
INFMOR	Infant mortality rate
HLSTUNT	Percentage of population stunted
MALNCHP	Percentage of children undernourished
MALNPOPP	Percentage of population undernourished
HLBMI	Body Mass Index
HLOBESITY	Percentage of population obese
HLSMOKING	Percentage of population that smokes

measure is insufficient in understanding the full impact of ill health. For this reason, it is also possible to break down the actual number of deaths accruing to each cohort, sex, and cause via the Specialized Display menu under the health heading. For example, both the Mortality by Age, Sex, and Cause and the J-Curve displays provide useful information about the health status of a country.

Three other measures help to enrich the picture: **HLYLL**, **HLYLD** and **HLDALY**. Like **DEATHCAT**, these aggregate (across age-cohort) measures are available by cause and country. **HLYLL** is a measure of the number of life years lost due to premature death. It differs from the **DEATHCAT** variable because it represents the burden of premature mortality in terms of life years lost, which allows us to account for the fact that some diseases, like HIV/AIDS, primarily affect younger people, while others, like cardiovascular disease, are primarily fatal in older adults. Although the total number of deaths may be the same between two countries for each cause, there may be significant differences between two countries' health profiles in terms of YLLs.

HLYLD is another measure that represents the burden of ill health in terms of life years of impact. It indicates the burden of years lived with disability or disease. In calculating YLD, IFs uses the disability weights that WHO created to rank the relative severity of different conditions and their impact on productivity.

Finally, Disability Adjusted Life Years (DALYs) are a measure of morbidity (disability or infirmity due to ill health). **HLDALY** sums YLLs and YLDs to create a measure of the number of years of life lost to both premature mortality and morbidity due to ill health. Like the other measures discussed above, DALYs can be broken down by different disease categories within IFs. The DALY is probably the most expansive measure of ill-health within a population because it includes mortality burden by age of death and the lost quality of life for those who did not die from health events, but who are disabled by them in some way.

Other measures provide indicators of health in regard to certain specific risk factors for disease or among certain segments of the population. Infant mortality, **INFMOR**, can be used to assess the burden of ill health among children under one year of age. **HLSTUNT**, displays the percentage of the population who are stunted (have low height for age),while **MALNCHP** and **MALNPOPP**, provide information on the percentage of the child and adult population who are undernourished respectively. The variables **INFMOR, HLSTUNT** and **MALNCHP** are especially useful for assessing the burden of ill health due to communicable diseases and other conditions that primarily affect children. By contrast, the variables **HLBMI**, **HLOBESITY**, and **HLSMOKING** provide risk factor information on diseases that affect primarily adults. **HLBMI** represents the body mass index in a country while **HLOBESITY** and **HLSMOKING** provide information on the percentage of the population that is obese or smokes.

Other variables that will be useful to users interested in specific conditions or subpopulations include indicators on stunting and BMI, as well as smoking and obesity. Variables for HIV/AIDS are also available and discussed separately below in the subsection on the [HIV/AIDS](#) sub-module.

Parameters to Affect Overall Health and Burden of Disease

Parameter	Variable of Interest	Description	Type
hlmortm	DEATHCAT/ HLYLL/HLDALY	Multiplier on Mortality (by cause)	Multiplier
hlmorbm	HLYLL/HLYLD	Multiplier on morbidity	Multiplier
hlstddthsw	DEATHCAT	Switches DEATHCAT from absolute numbers to deaths/1000	Switch

The above parameters provide simple ways to directly affect the burden of disease within a country. The most important parameter for modifying mortality rates is **hlmortm**, a parameter that allows users to increase or decrease the prevalence of deaths in any particular category of illness. IFs modifies mortality in the following categories: Other Communicable Disease, Malignant Neoplasm, Cardiovascular, Digestive, Respiratory, Other Non-Communicable Diseases, Unintentional Injuries, Intentional Injuries, diabetes, AIDs, Diarrhea, Malaria, Respiratory Infections, and Mental Health. Altering the mortality burden will affect the variables **DEATHCAT**, **HLYLL**, and **HLDALYs**. The parameter will indirectly affect morbidity because of its direct link to mortality. In the case of Mental Health Diseases, the parameter will not have much impact on **DEATHCAT**, but may have a significant impact on the number of DALY's experienced by a population. Because **hlmortm** is a multiplier, increasing its value from 1 to 1.2 represents a 20% increase in the burden of mortality from a particular cause. A similar parameter, **hlmorbm**, allows users to affect morbidity directly through a brute force multiplicative parameter. This allows users to affect the years lost to disability in a working life and by extension multifactor productivity due to human capital (**MFPHC**). The **hlstddthsw** allows users to switch between displaying DEATHCAT in absolute numbers to deaths per thousand people.

Parameters that Affect Communicable Diseases

Parameter	Variable of Interest	Description	Type
watsafem	WATSAFE, INFMOR	Percentage of population with access to safe water	Multiplier
sanitationm	SANITATION, INFMOR	Percentage of population with access to improved sanitation	Multiplier
malnelimstartyr	MALNPOPP	Undernourishment elimination start year	Standard error
malnelimtargetyr	MALNPOPP	Undernourishment elimination target year	Standard error
malelimprecisesw	MALNPOPP	Undernourishment elimination	Switch
ylm	YL	Yield multiplier on agriculture	Multiplier
hivm	HIVCASES	Rate of HIV infection	Multiplier
clpccvm	CLPCCV, MALNPOPP	Multiplier on coefficient of variation for calories per capita	Multiplier

Above are a number of the parameters that users may wish to use to manipulate communicable diseases (which predominantly affect children). **Ylm** is a multiplicative parameter in the agriculture module that can be used to change the yield of agricultural lands within a country, affecting the number of calories available for consumption, and thereby altering the rates of malnutrition and obesity. **Clpccvm** is another parameter in the agriculture module that impacts the calories per capita available, and also alters the rate of malnutrition by changing the distribution of caloric consumption for a country/region. **Watsafem** and **sanitationm**, in the infrastructure module, influence the percentage of the population that has access to safe water and sanitation respectively, thus decreasing childhood exposure to diarrheal disease, malnutrition and premature death. Other parameters to control safe water and sanitation access are discussed in the infrastructure section of the model.

Finally, although HIV is more thoroughly discussed in the HIV/AIDs submodule, one brute force parameter is worth noting here. **Hivm** allows users to directly affect the rate of infection with the HIV virus.

Parameters that Affect Non-communicable Disease

Parameter	Variable of Interest	Description	Type
envpm2pt5m	ENVPM2PT5	Changes levels of environmental pollution	Multiplier
hlsmokingm	HLSMOKING	Changes rate of smoking	Multiplier
hlobesitym	HLOBESITY	Prevalence of obesity	Multiplier
hlbmim	HLBMI	Multiplier on body mass index	Multiplier

Hlsmokingm is a multiplicative parameter that will change the rate of smoking, which will affect the prevalence of respiratory diseases. **Envpm2pt5m** is a multiplicative parameter that will change the level of ambient environmental pollution in terms of parts per million; higher levels of environmental pollution are a risk factor for both communicable and non-communicable respiratory diseases.

Hlobesitym works similarly to affect the prevalence of obesity within a society in the absence of overall caloric intake changes. This parameter can be used to model the impact of changing levels of physical activity within a society. Both of the above parameters work similarly to other multiplicative parameters: increasing the value of

the parameter to 1.2 from 1, represents a 20% increase in the value of the parameter over the base case. By the same token, users can use **hlbmim** to affect the body mass index in a country, a major risk factor for cardiovascular diseases, diabetes, and overall morbidity. Please note: **hlobesitym** affects only obesity rates and *has no effect* on health; in contrast, **hlbmim** will affect body mass index, obesity, and deaths from heart disease and diabetes.

Parameters that Affect Injuries and Accidents

Parameter	Variable of Interest	Description	Type
deathtrpvm	DEATHTRPV	Multiplier on traffic deaths per vehicle	Multiplier
deathtrpvsetar, deathtrpseyrtar	DEATHTRPV	Standard error target for traffic deaths per vehicle	Relative target Value/Year

Only a small set of parameters allow users to affect injuries and accidents, and these primarily revolve around reducing traffic deaths. Users may reduce traffic deaths as a ratio of the number of vehicles in a country using either a multiplier, **deathtrpvm**, or a pair of standard error targeting parameters, **deathtrpvsetar** and **deathtrpseyrtar**. Standard error targeting is discussed in detail in the infrastructure module. These parameters allow users to model the impact of road safety on mortality and, by extension, on economic productivity.

Parameters to Affect Technology

Parameter	Variable of Interest	Description	Type
hlmortmodsw	CDR	Reduces crude death rate in Africa, Europe, Southeast Asia, West Pacific	Switch
hltechshift	CDR	Rate of change in health technology	Additive factor
hltechlinc	CDR	Rate of change in health technology in low income countries	Additive factor
hltechssa	CDR	Rate of change in health technology in Sub-Saharan Africa	Additive factor
hltechbase	CDR	Rate of change in health technology at base	Exogenous specification

Aside from the direct and indirect parameters affecting health, the distal drivers of health include per capita GDP, years of education, and technology. Per capita GDP is an element of the economic module and can be changed in a number of ways, but especially by changing the elements that make up multifactor productivity. Years of education is an element of the education module and can be changed by altering the duration of schooling, and the completion rate.

Moving to the third distal driver of health, there are a number of parameters built into the health module that can be used to alter the rate of technological change. **Hlmortmodsw** is a master switch that, when set to 1 as in the Base Case default, reduces technological progress for low-income countries of Africa, Europe, Southeast Asia, and West Pacific based on geographic and income categories. There are parameters available to alter these assumptions about differentials in mortality declines in these regions, but they only have an effect in the base case; when **hlmortmodsw** is set to 0 these parameters have no impact.

Once **hlmortmodsw** is set to 1, users can manipulate mortality patterns through several parameters. **Hltechshift**, alters the rate of change for health technology impacts relative to GDP. The **hltechshift** parameter allows users to change the mortality rate using a shift parameter that alters the technology factor affecting mortality decline

relative to initial GDP. **Hltechlinc** and **hltechssa** can be used to change the rate of technological advance resulting in mortality decline in low-income countries (**hltechlinc**) and sub-Saharan Africa (**hltechssa**) specifically. Meanwhile, the **hltechbase** parameter allows users to change the base level of technological change across the world, rather than country by country as you can do using the **hltechshift** parameter. All of these parameters pertain to all causes of mortality except cardiovascular mortality, which uses a different regression equation.

Prepackaged Scenarios

Three major integrated scenarios on health were developed by the Pardee Center for the health volume of the Patterns of Potential Human Progress series (Hughes et al., 2011). The World Integrated Scenario Sets folder contains the scenarios that were built for this volume, of which three are worth an extended discussion. The first is the Proximate Drivers Excluding Environment folder, which contains parameters to individually alter four of the major risk factors for several causes of mortality. These are Body Mass Index which is a risk factor for cardiovascular disease; under nutrition, which is a risk factor for communicable diseases; smoking which is a risk factor for respiratory disease; and large increases in the number of cars per person coupled with poor pedestrian safety, which is a major risk factor for accidental death. This scenario also includes increased to improved water sources and piped sanitation taken from the infrastructure module, and parameters to reduce environmental exposure to poor air quality. This scenario reduces these risk factors to their theoretical minima, to simulate aggressive efforts to reduce, high BMI, the obesity rate, childhood malnutrition, smoking, and traffic mortality. Malnutrition is set to 0.01, smoking and obesity multipliers are set to 0, BMI multiplier to 0.8, vehicle fleets to 0.5, and traffic mortality to 0.

Another important pair of prepackaged scenarios contains the optimistic Luck and Enlightenment scenario, and a scenario that considers what happens when Things Go Wrong. The Luck and Enlightenment scenario includes improvements to HIV/AIDS, sanitation access, improved air quality, and reduced smoking rates which help lower the burden of NCDs. It also features changes to the burden of communicable disease designed to increase the levels of these. A variation to Luck and Enlightenment has add-ins that also increase foreign aid donations and agricultural yields, effectively modeling a situation in which increased global cooperation supports these efforts. Things Go Wrong models a world in which air quality worsens, smoking and obesity rates increase and there is little international cooperation on addressing these challenges.

HIV/AIDS Submodule

Variables of Interest

HIV and AIDS have attracted significant interest among policy makers because of the tremendous toll that these diseases have on populations in both human and economic terms. Because of this interest, it is worth discussing the HIV/AIDS submodule separately from the rest of the health module. That submodule represents both the extent of HIV prevalence in a population (a stock variable) and the annual deaths from AIDS (a flow variable driven in substantial part by the prevalence rate, but also responsive to technological advance in the fight against AIDS). A number of key variables are available to represent the burden of HIV and AIDS within a country.

Variable Name	Description
HIVCASES	Number of HIV cases
HIVRATE	HIV infection rate
HIVTECCNTL	Rate of technical control of infection, cumulative reduction in infection rate
AIDSDTHS	Number of AIDS deaths
AIDSDRATE	Death rate from AIDS
AIDSDTHSCM	Cumulative Number of AIDS deaths since first year of model

Three variables are key to understanding the progression of infection within a country. **HIVCASES** provides the total number of HIV cases, **HIVRATE** represents a flow variable showing the rate at which people are being infected with HIV, and **HIVTECCNTL** indicates the progress being made in reducing the rate of infection within a country.

Three other variables assess mortality due to HIV and AIDs within a country. Similar to HIV, the variables **AIDSDTHS** and **AIDSDRATE** indicate the number of AIDs deaths and the rate of mortality from AIDs respectively, while **AIDSDTHSCM** represents the cumulative number of deaths due to the disease.

Parameters to Affect Prevalence

Parameter	Variable of Interest	Description	Type
hivm	HIVRATE	HIV infection rate, multiplier of percent of population infected	Multiplier
hivtadvr	HIV CASES/ HIVRATE	Technical advance rate in of control of infection	Rate of change
hivpeakr	HIVCASES/ HIVRATE	HIV infection rate at year of peak	Target value
hivpeakyr	HIVRATE	Sets year of epidemic peak	Target year
hivincr	HIVCASES	HIV increase rate, only used prior to 2000	Rate of change

Modifying the infection rate with **hivm** is probably the easiest way to adjust the burden of HIV infection within a country. Like **hlmortm**, **hivm** is a multiplicative parameter. In other words, increasing the value of the parameter in scenario analysis from 1 to 1.2 represents a 20% increase in the rate of infection relative to the base case. **Hivtadvr** allows users to change the prevalence of HIV, once the epidemic has peaked, by a certain percent annually to model different assumptions about the rate at which control technologies will improve, reducing the prevalence of the disease over time. Unlike the mortality multiplier, which takes effect once the model has calculated the base

case, this parameter will affect the actual calculations the model makes while running. This parameter functions as additive factor to a growth rate within IFs. In other words, a 0.01 increase in the parameter represents a 0.01 increase in the growth rate for the technical advance rate in HIV infection control (**hivtadvr**).

The HIV submodule is designed to allow users to affect the course of the epidemic across countries and across time. One way to alter the course of the epidemic is by manipulating the coefficient on **hivpeakr**, which is an additive parameter that will increase the peak rate of infection over the course of the epidemic. Thus a 0.01 increase in the value of the coefficient represents a 0.01 increase in the peak infection rate. An associated parameter, **hivpeakyr** sets the date at which the epidemic will peak before the infection rate begins to decline. Changing this parameter in the Scenario Analysis page will allow users to set any year between 2010 and 2100 as the year of peak infection rate depending on their assumptions regarding the technical rate of advance in controlling the disease. Finally, the parameter **hivincr** controls the increased rate in infection prior to 2000, when our knowledge of the epidemic was much less complete and control efforts were far less effective. It is important to note that the parameter hivpeakr must be used in combination with parameters, hivpeakyr and hivincr.

Parameters to Affect Mortality

Parameter	Variable of Interest	Description	Type
aidsdrtadvr	AIDSDTHS/ AIDSDRATE	AIDs death rate, technical annual advance rate in control	Rate of change
aidsdratem	AIDSDRATE	AIDs death rate as % of HIV infection rate, multiplier	Multiplier

Just as there are a variety of parameters available to control the prevalence of HIV within a population, there are also a number of parameters that allow users to control the lethality of the epidemic. The first of these parameters allow user to change the death rate as a percentage of the infection rate via the parameter **aidsdratem**. This parameter directly alters the lethality of the disease; it serves as a proxy for the presence or absence of control measures within a country since the availability of anti-retroviral medications will affect the rate at which people who are HIV positive die from AIDs. Of course, new research strongly suggests that ART therapies may also significantly reduce the HIV infection rate as well, but because these are not yet linked in the model, users should be aware that a more realistic use of this parameter would alter not only the AIDs mortality rate, but the infection rate as well. The other parameter available to users to control mortality from AIDs is **aidsdrtadvr**, a parameter which changes the technical annual advance rate in control. This parameter simulates the annual advance in technologies to control AIDs mortality, altering the lethality of the disease.

Prepackaged Scenarios

There are several prepackaged scenarios that deal with the HIV/AIDS epidemic. The first, under the heading HIV/AIDS in the Technological Advance section of the Framing Scenarios folder, models two scenarios around technological advance to control the epidemic. One models rapid technical advances to control HIV infection, while the other presents a scenario in which technological progress slows, slowing the resulting decline in infections.

A second set of prepackaged scenarios are available to affect HIV/AIDS are focused on altering the course of the epidemic in key countries, rather than at a global level. They are called: Intermediate HIV/AIDS, Intermediate for New School Paper, Severe HIV Aids and Total Failure to Control HIV AIDs and are located in the Surprises and Wildcards folder, under the heading AIDs. These scenarios modify the course of the AIDS epidemic in Russia, China, India, and the world at large. Each one affects parameters controlling the infection rate at the peak year of the epidemic, the peak infection rate, the initial rate of infection, the rate of advance in the infection, and the elasticity of multifactor productivity to life expectancy. They give a good example of how to modify combinations of parameters in specific countries to create different trajectories for the epidemic.

Severe Acute Malnutrition (SAM) Submodule

In addition to the prevalence and incidence of the above mentioned diseases, IFs also calculates the prevalence and incidence of severe acute malnutrition (SAM) and its impact on productivity. Severe Acute Malnutrition (SAM) (also known as severe wasting) is a deficiency of protein or other minerals and vitamins leading to a loss of body fats and muscle tissues. SAM can be defined by a Weight-for-Height Z-score <-3 compared to the median WHO growth standards; by visible severe wasting; or by the presence of nutritional oedema (Prudhon, Briend, Prinzo, Daelmans, & Mason, 2006). It has been identified as a significant cause of death and disability globally (Black et al., 2008, 2013).

The key variables to understanding the impact of the disease are the prevalence of SAM (MALNCHPSAM), the number of cases of SAM that occur in a particular year or the incidence of the disease (MALNCHPSAMINC), the number of people who are admitted for treatment for the disease in a particular year (SAMADMISSION) and the number of cases where SAM is averted (SAMAVERTED). Since the disease itself shares a relationship with stunting, the model also allows the user to explore the extent to which SAM affects stunting (HLSTUNT) and malnutrition (MALNCHP).

The table below explains the key variables in this sub-module,

Variable Name	Description
MALNCHPSAM	Prevalence of SAM
MALNCHPSAMINC	Annual new number of cases of SAM
SAMADMISSION	Total national number of admissions for treatment
SAMAVERTED	Success of treatment as a percent of total admission

Parameters to affect prevalence and incidence

Parameter	Variable of Interest	Description	Type
malnchpsamadj	MALNCHPSAMINC	Used to adjust the incidence correction factor	Adjustment factor
malnchpsamm	MALNCHPSAM	Used to change prevalence of SAM	Multiplier

The easiest lever a user can pull to influence prevalence of SAM is the multiplier *malnchpsamadj* which can directly increase or reduce the number of prevalent cases of the disease. Incidence of SAM is calculated by applying a correction factor on the prevalence rate. The user can adjust the correction rate thereby influencing incidence of the disease using the adjustment factor **malnchpsamadj.**

Parameters to affect admissions and treatment

Parameter	Variable of Interest	Description	Type
samadmissionadd	SAMADMISSION	Used to increase or decrease the number of admissions for treatment	Additive factor

samadmissionm	SAMADMISSION	Used to increase or decrease the number of admissions for treatment	Multiplier
samadmissionsw	SAMADMISSION	Allows users to forecast SAM admissions in three ways (0) forecasts all countries according to the relationship with GDPPCP, (1) holds all initial zero values constant over time (default value), and (2) holds all initial values constant.	Switch
samavertedconvyr	SAMAVERTED	Allows users to change the years to converge to 100	Convergence factor
samavertedm	SAMAVERTED	Allows users to change the number of averted cases	Multiplier

There are two parameters available for changing the number of admissions for treatment, *samadmissionadd* which is an additive factor and *samadmissionm* which is a multiplicative factor. Further, the user can forecast the number of admissions using the GDP per capita or by holding all initial zero values constant over time or by holding all initial values constant through the manipulation of the switch *samadmissionsw.*

When it comes to the number of cases that are cured, the model assumes a success rate to converge to 100 percent over a 100-year time horizon. The user can change the speed of convergence through the parameter *samavertedconvyr.* Finally, the user can change the number of cases averted using a brute force multiplier *samavertedm.*

Relationship between malnutrition, stunting and SAM

Parameter	Variable of Interest	Description	Type
malnchpsamtostunt	HLSTUNTCHL and HLSTUNT	Controls the degree to which MALNCHPSAM affects HLSTUNT	Adjustment factor
samrrsw	HLSTUNT and DEATHS	Used to substitute the severity of MALNCHP with that of MALNCHPSAM	Switch
samtomalnchpsw	MALNCHP	allows users to specify scenarios in which successful treatment does not result in full weight	Switch

The adjustment factor *malnchpsamtostunt* allows the user to change the extent to which SAM affects stunting in the population. IFs calculates rates of stunting using a slow moving average using the number of undernourished children, the prevalence of SAM, the number of years for which stunting is expected to occur and the relevant height for age. The activation of the switch *samrrsw* substitutes the severity of undernourishment for undernourished children (MALNCHP) with the severity of SAM (MALNCHPSAM). Severity here refers to the relative risk of mortality and morbidity. This switch allows the user to explore the possible severity of the disease. For a more detailed description of this parameter, refer section 6.1.1 of the Health Model documentation.

By default, it is assumed that all successfully averted SAM cases are rehabilitated to normal weight for age. Changing the parameter *samtomalnchpsw* allows users to specify scenarios in which successful treatment does not result in full weight (for age) rehabilitation, with a value of 1 resulting in all averted SAM cases remaining malnourished (by default this parameter is set to 0).

Education Module

Variables of Interest

Like all of IFs, the education module is amenable to systems thinking, or conceptualizing elements as stocks and flows. Students flow through primary, lower-secondary, upper-secondary and tertiary education levels. Each time an age cohort completes a grade level, a year is added to that group's stock of educational attainment; as adults (aged either 15 and older or 25 and older) they will have attained some number of years of formal education based on grades completed. For any given grade, the number of students enrolled is determined by the intake rate—or, at the secondary level, the transition rate from the previous level of education—and by the percentage of students passing through the last grade. Government spending influences the system by restraining the number of students that can be sustained at a given level of education.

Most analysis of the international education system focuses on educational attainment. IFs operationalizes this stock as the average years of education successfully completed by adults in all countries, following a typology designed by Harvard economists Robert Barro and Jong-Wha Lee (2000, 2001). **EDYRSAG15** captures the mean years of education

Variable Name	Description
EDYRSAG15 **EDYRSAG25** **EDYRSAG15TO24**	Educational attainment, adults by age group
EDPRIPER **EDSECPER** **EDTERPER**	Percent of the population completing primary, secondary and tertiary
EDPRIENRG **EDSECENRG** **EDSECLOWRENRG** **EDSECUPPRENRG** **EDTERENRG**	Gross enrolment rate in primary, secondary, lower secondary, upper secondary and tertiary
EDPRIENRN **EDSECENRN**	Net enrolment rate in primary, secondary
EDPRIINT **EDPRIINTN** **EDTERINT**	Primary intake rates, gross and net, and tertiary intake rates, gross
EDSECLOWRTRAN **EDSECUPPRTRAN**	Transition rates from primary to lower secondary and from lowers secondary to upper secondary
EDPRISUR **EDSECLOWRSUR** **EDSECUPPRSUR**	Survival rates for primary, lower secondary, upper secondary
EDPRICR, **EDSECLOWRGRATE,** **EDSECUPPRGRATE,** **EDTERGRATE**	Graduation rates in primary, lower, secondary, upper secondary and tertiary
EDSECLOWRVOC, **EDSECUPPRVOC**	Vocational enrollment rates, lower and upper secondary
EDEXPERPRI **EDEXPERSEC** **EDEXPERTER**	Government spending per student as a percentage of GDP for primary, secondary and tertiary
GDSED	Spending shares by level of education

attained for all adults older than 15; this important variable links forward to several other sectors of the model, including economics through multifactor productivity, health through fertility rate, and even governance through state fragility indicators. Users may wish to view mean years of education by other age breakdowns, available through **EDYRSAG25** and **EDYRSAG15TO24** though these variables do not have the forward linkages in the model that **EDYRSAG15** does. As an alternative to average years of education, **EDPRIPER, EDSECPER and EDTERPER** track attainment as a percentage of the population to successfully complete each level of education.

In addition to attainment measures, most users will focus their attention on enrolment rates, the most common measure of student flows. Enrolment rates answer the simple question: at a given time, how many children are in school?

Enrollment is captured in the variables **EDPRIENRG** and **EDPRIENRN** for primary, **EDSECENRG**, **EDSECENRN**, **EDSECLOWERENRG** and **EDSECUPPRENRG** for secondary and **EDTERENRG** for the tertiary level**.** Many of the indicators used to measure education systems are either gross rates or net rates. This important distinction has to do with student age. Gross Enrollment Rates (GER), for example, are calculated by dividing the total student body by the official school-age population; Angola's primary GER would be the number of primary students enrolled in school divided by the primary age population of the country and has often exceeded 100 percent because of primary enrollment by over-aged students who enter or return to school for various reasons. Net Enrollment Rates (NER), on the other hand, measure only the students of official school age. A country's NER is the enrolled age-appropriate students divided by only the school-age population and should not exceed 100 percent. Net enrolment data are often more difficult to find than gross, simply because it requires the age of enrollees to calculate. Intake rates are also presented in both net and gross formulations. For a more detailed description of commonly used education indicators see UNESCO's technical guidelines: http://www.uis.unesco.org/Library/Documents/eiguide09-en.pdf.

For each of the countries in IFs, two factors ultimately control enrolment rates: intake rates and survival rates. Drawing on drivers such as GDP per capita and educational spending, the model forecasts intake rates for primary and tertiary levels (**EDPRIINT, EDPRIINTN, and EDTERINT**) and transition rates from the previous level of schooling for secondary education (**EDECLOWRTRAN EDSECUPPRTRAN**). The model also forecasts a student persistence rate for all levels (except tertiary), often referred to as survival rate, captured in the variables **EDPRISUR**, **EDSECLOWRSUR**, and **EDSECUPPRSUR**. Enrolment rates at each level are calculated as the combined result of these student flows. Or thought of more simply, enrolment rates track the number of students who enter school and stay in school. Graduation rates at all levels are also forecast and the corresponding variables are: EDPRICR, **EDSECLOWRGRATE**, **EDSECUPPRGRATE** and **EDTERGRATE**. The model also forecasts vocational shares in lower secondary and upper secondary and the variables are **EDSEECLOWRVOC** and **EDSECUPPRVOC**.

All indicators in the model that measure the stock of educational attainment or student flows can be disaggregated by gender. Thus, the user is able to evaluate each country's progress toward eliminating gender-based disparity in the classroom. In order to disaggregate performance by gender, a second dimension of almost all education variables allows the selection of display by male, female or total. In addition to setting normative goals, separate treatment of female education allows the model to establish powerful forward linkages. For example, female educational attainment and fertility rates are negatively related, because schooling increases the opportunity cost of having and raising a child.

In addition to student flows, the model captures financial flows tied to each country's education system. Educational finance is the result of interplay between supply-side and demand-side forces. Demand for education can be conceptualized as the product of spending per student and enrollment rates at each level of schooling—**EDEXPERPRI, EDEXPERSEC** and **EDEXPERTER** track spending per student as a percent of GDP per capita for primary, secondary and tertiary education. However, such a formulation of demand is crude, as the number of children already in the system is constrained by the preexisting structure of government spending. Financial supply, captured as a percent of GDP by the variable **GDSED**, is generated by the government finance submodule. Due to a lack of reliable data, IFs does not capture private educational funding, though it is important in some countries.

Parameters to Affect Intake Rates and Survival Rates: Annual Growth

Parameter	Variable of Interest	Description	Type
edpriintngr	EDPRIINTN	Primary net intake rate	Annual growth
edterintgr	EDTERINT	Tertiary intake rate	Annual growth
edseclowrtrangr	EDSECLOWRTRAN	Lower secondary transition rate	Annual growth
edsecupprtrangr	EDSECUPPRTRAN	Upper secondary transition rate	Annual growth
edprisurgr	EDPRISUR	Primary survival rate	Annual growth
edtergradgr	EDTERGRADS	Tertiary graduation rates	Annual growth

In the IFs model, improved education outcomes can be achieved most directly through changes to intake and survival rates. The number of students entering the first grade of each schooling level can be pushed up or down using annual (percentage point) growth parameters: **edpriintngr** for primary school, **edseclowrtrangr** for transfer rates between primary and secondary, **edsecupprtrangr** for transition between lower and upper secondary and **edterintgr** for intake into the tertiary level. However, any improvements to enrolment stemming from intake rate boosts are restrained when coupled with high dropout or repetition rates. Like intake rates, survival rates can be directly manipulated through annual growth parameters. **Edprisurgr** controls survival growth (in percentage points) at the primary level. And finally, **edtergradgr** controls tertiary survival rates (also referred to as graduation rates).

Though intake rates and survival rates can be manipulated separately, users will often wish to manipulate them in conjunction due to the presence of interaction effects between the two sets of variables. For example, a rapid increase in intake/transition rates can result in a decline in country's survival rate. The educational system may simply not have the resources to cope with an influx of students. Furthermore, the incoming cohort, which has spent years outside the system, may represent individuals from disadvantaged backgrounds—a group prone to dropping out. On the other hand, rising intake rates may have a positive threshold effect on survival rates. In many countries, once intake rates reach a certain level, dropout and repetition have declined. At this time such relationships are not captured in IFs. Thus, the user may want to build interaction and threshold effects into education policy interventions.

Parameters to Affect Intake Rates and Survival Rates: Target Year for Universal Education

Parameter	Variable of Interest	Description	Type
edpriintntrgtyr	EDPRIINTN	Primary net intake rate	No. of years to reach 100%
edseclowrtrantrgtyr	EDSECLOWRTRAN	Lower secondary transition rate	No. of years to reach 100%
edsecupprtrantrgtyr	EDSECUPPRTRAN	Upper secondary transition rate	No. of years to reach 100%
edterinttrgtyr	EDTERINT	Tertiary Intake Rate	No. of years to reach 100%
edprisurtrgtyr	EDPRISUR	Primary survival rate	No. of years to reach 100%
edtergradtrgtyr	EDTERGRAD	Tertiary graduation rates	No. of years to reach 100%

Development goals like universal access to education with a specific target date can be explored through target year parameters on intake (transition) or survival (graduation) rates. These parameters ramp up the base year value of the variable of interest to one hundred percent within the number of years marked by the parameter. For countries with limited availability of government resources, these target parameters might need an education budget set aside through the edbudgon parameter described later in the budget sub-section.

Parameters to Affect Intake Rates and Survival Rates: Multiplier

Parameter	Variable of Interest	Description	Type
edpriintnm	EDPRIINTN	Primary net intake rate	Multiplier on base case
edterintm	EDTERINT	Tertiary intake rate	Multiplier on base case
edseclowrtranm	EDSECLOWRTRAN	Lower secondary transition rate	Multiplier on base case
edsecupprtranm	EDSECUPPRTRAN	Upper secondary transition rate	Multiplier on base case
edprisurm	EDPRISUR	Primary survival rate	Multiplier on base case
edtergradm	EDTERGRAD	Tertiary survival rates	Multiplier on base case

In addition to the growth and target parameters described above, intake (or transition) and survival (or graduation) rates can also be modified using a set of multipliers listed in the table above. Like other multipliers in the model these work by ramping up (or down) the base case forecast over a horizon chosen in the scenario design.

Parameters to Affect Education Spending

Parameter	Variable of Interest	Description	Type
gdsm (education)	GDS	Government spending on education	Multiplier
edbudgon	GDS	Education funding impact and priority	Exogenous specification
gdsedm	GDSED	Government spending on education by level	Multiplier
edexppconv	EDEXPERPRI	Education spending per student, primary	Convergence speed
edexpslconv	EDEXPERSEC	Education spending per student, secondary	Convergence speed
edexpsuconv	EDEXPERSEC	Education spending per student, secondary	Convergence speed
edexptconv	EDEXPERTER	Education spending per student, tertiary	Convergence speed
edqtqltrm	EDEXPERPRI, EDEXPERSEC , EDEXPERTER and GDS	Education quantity-quality balance	Multiplier

Attainment levels also respond indirectly to changes in the educational spending structure. The number of students enrolled at all grade levels is constrained by total public spending on education. In IFs, public finance allocations are distributed between transfer payments, the military, education, health and infrastructure in the government budget submodule. Bottom-up factors like demographic changes and policies targeting intake or survival will pressure the government to increase education spending. But the model features somewhat rigid top-down control of the budget—spending on education competes with other government spending and IFs maintains accounting of both total government revenues and expenditures. Most countries spend something close to the global average of 5 percent of GDP on education each year. Thus demand-side shifts may secure an increase in resources, but it is difficult to increase total education spending much in excess of historically observed values. Users can intervene in this accounting process by manipulating **gdsm (education)**, a multiplier that directly

increases the share of government expenditure accounted for by education, at the expense of spending in other arenas such as military or health. Alternatively, users can prioritize education spending over other government expenditure targets. The priority parameter **edbudgon**, takes on values from zero to one, with lower values representing lower priority to education funding demands and one representing maximum priority. Any non-zero value pushes education allocations away from those determined by historical spending patterns and level of economic development—as calculated in the economic module—and toward the bottom-up demand for expenditures calculated in the education model. The parameter **edbudgon** can also be used to completely turn off the budget impacts on student flow rates through a zero value of the parameter. The turning off of budget impacts is helpful in projecting the demand for funds for certain types of education intervention, e.g., universal primary education. However, fund demand in such a scenario is calculated in the EDTOTCOST and not in the GDS(Education) variable, which is determined, in this case, completely through the government budget allocation algorithm without using any input from the education model.

The government-budget submodule automatically allocates resources to the educational level most in need (although that interacts with historical patterns of educational preference), starting with primary education. As enrolment rates in a country's primary education system reach a very high level, the model reallocates funding up the chain to secondary. Users may wish to change this pattern and create normative scenarios that prioritize higher levels of education, or balance spending between primary, secondary and tertiary. The **gdsedm** parameter allows for such experimentation via a second dimension that allots the spending increase to a specific level of schooling.

When developing education budgets, planners must account for trade-offs between equity and efficiency. What is more important, increasing total spending on the system in an effort to support more students, or increasing spending per student in an effort to improve the experience of being in school? In a crude way this can be thought of as the difference between increasing intake and increasing survival rates. IFs includes parameters that shift the spending focus in the direction of system efficiency. **Edexppconv** can be used to decrease the time it takes a country's initial spending per primary student to converge with the model's expected function. **Edexppslconv** and **edexppuconv** control the student expenditure function for lower and upper secondary, and **edexpptconv** does the same for the tertiary level. Increasing the target value used in a convergence parameter will increase per student spending for countries below the expected value, but the opposite is true in countries exhibiting higher than expected values. If a user wishes to boost per student expenditure in a high performing country, he or she should make use of the **edqtqltrm** parameter, a multiplier that shifts emphasis away from education quantity and towards education quality—with values less than one indicating a shift towards quality.

Parameters to Affect Gender Parity

Parameter	Variable of Interest	Description	Type
edprigndreqintn	EDPRIINTN	Gender parity for primary intake	Convergence speed
edprigndreqsur	EDPRISUR	Gender parity for primary survival	Convergence speed
edseclowrgndreqtran	EDSECLOWRTRAN	Gender parity for lower secondary transition	Convergence speed
edsecupprgndreqtran	EDSECUPPRTRAN	Gender parity for upper secondary transition	Convergence speed
edtergndreqint	EDTERINT	Gender parity for tertiary intake	Convergence speed
edtergndreqgrad	EDTERSUR	Gender parity for tertiary survival	Convergence speed

Some development projects focus on gender disparity in education, rather than aggregate enrolment. In recent decades male and female enrolment rates have converged rapidly across all regions of the world. In fact, primary, secondary and tertiary enrolment taken as a global aggregate has already surpassed a female-male ratio of 0.97—commonly considered an indicator of parity. However this abstracted view obscures struggles facing women in low-performing areas, especially sub-Saharan Africa. Users may explore effects linked to improvements in female-specific enrolment rates via the intake and survival parameters described above; each parameter has a dimension that applies the annual increase to males, females, or the total student population. Alternatively, users can experiment with closing the gender attainment gap existing in some countries by setting time sensitive goals. Goals around intake can be set through **edprigndreqintn** for primary, **edsecupprgndreqtran** for secondary and **edtergndreqint** for the tertiary level. Gender conversion goals may also be set for the other direct driver of enrolment, survival rates: **edprigndreqsur** controls female survival rates at the primary level**,** and **edtergndreqgrad** controls tertiary rates. Each of the gender-focused parameters are convergence speed goals, meaning the user sets the number of years that will elapse before the country's gender parity in the corresponding measure converges to the expected function.

Parameters to Affect Education Quality

Parameter	Variable of Interest	Description	Type
edqualpriallm	EDQUALPRIALL and EDQUALAG15PRI	Multiplier on primary education learning quality	Multiplier
edqualsecallm	EDQUALSECALL and EDQUALAG15SEC	Multiplier on secondary education learning quality	Multiplier
edqualag15m	EDQUALAG15	Multiplier on total learning quality for adults	Multiplier
mfpedqual	MFPHC	Elasticity of multifactor productivity to quality of education	Elasticity

In addition to the education model described above IFs also has a representation of learning quality. Learning quality is represented at the primary, secondary levels and for the adult population as a whole, for both sexes for four categories (math, science, reading and total). There is also a linkage from education quality to multifactor productivity.

Users can build scenarios with increased or decreased levels of learning quality through the multipliers **edqualpriallm (**learning quality at the primary level), **edqualsecallm**(learning quality at the secondary level) and **edqualag15m** (learning quality for the adult population as a whole). Users can change the elasticity of learning quality to multifactor productivity using the parameter **mfpedqual**.

Parameters to Affect Education Grade-Level Model

Parameter	Variable of Interest	Description	Type
edmodelsw	N/A	Education switch between old and new model (0=old model; 1=new model)	Switch
edpridrpgrdm	EDPRICR / EDPRIDRPGRD / EDPRIENRGGRD	Education, primary, grade-specific dropout rate, multiplier base 1	Multiplier
edprienrgrdm	EDPRICR / EDPRIDRPGRD / EDPRIENRGGRD	Education, primary, grade-specific enrollment rate, multiplier base 1	Multiplier

edseclowrdrpgrdm	EDSECLOWRDRPGRD/ EDSECLOWRENRGGRD/ EDSECLOWRTOT	Education, lower secondary, grade-specific dropout rate, multiplier base 1	Multiplier
edseclowrenrgrdm	EDSECLOWRENRGGRD/ EDSECLOWRTOT	Education, lower secondary, grade-specific enrollment rate, multiplier base 1	Multiplier

Prepackaged Scenarios

An installation of IFs includes scenarios used in each entry in the Pardee Center's Potential Patterns of Human Progress (PPHP) series. Scenarios created for the education volume include: a best and worst case framing scenario; case study interventions in several countries and regions; high spending and low spending scenarios; and over twenty normative scenarios (Dickson et al., 2010). This section will briefly describe the parameters used to construct a single normative scenario titled, Norm Mar 1 2009.

Norm Mar 1 2009 simulates a worldwide improvement in educational performance through interventions to: intake rates, student persistence, gender parity and educational spending, including boosts to foreign aid. From 2010 to 2100, the parameter **edpriintngr** is set to 2.2, and **edprisurgr** is set to 1.2, setting up annual increases to primary school intake and survival rates. The scenario includes similar annual growth increases for intake and student persistence across lower secondary and upper secondary schooling. **Edseclowrtrangr** is set to one percent, **edsecupprtrangr** to 0.5 percent. The corresponding parameters for tertiary education are not assigned a value other than the default of zero. Additional interventions speed up the narrowing of persisting gender gaps in intake, survival and transition rates. The parameters **edprigndreqintn and edprigndreqsur** set a ten year time goal for gender parity at the primary level; **edseclowrgndreqtran** sets a thirteen year goal for parity at the lower secondary level; and, **edsecupprgndreqtran** sets a 20 year time goal for parity at the upper secondary level. In order to simulate improved education quality, across levels, **edexppconv, edexpslconv, edexpsuconv and edexptconv** all take the value of 20, signifying a convergence to the expected function after 20 forecast years. Because this scenario was created as a tool to explore the potential impacts of a world in which educational goals are achieved by all nations, the budget switch, **edbudgon**, is set to 0, the highest prioritization of education funding.

Economic Module

Variables of Interest

The treatment of economics in IFs draws on both the classical tradition's focus on economic growth (with great attention in IFs to the newer work on endogenous growth theory) and the neoclassical perspective's general equilibrium approach.

The economic module is a core component of the IFs system for multiple reasons, in particular for its close interactions with all other modules. On the input side, variables from almost all other modules affect production levels. On the output side, the magnitude of GDP and the level of GDP per capita are critical, in turn, for essentially all other modules. Mostly closely linked to the economic module are the energy and agriculture modules, both of which use a partial equilibrium structure that echoes the one in the economic module, and both of which provide physical values that fully determine the currency value-based representations of their respective sectors in the economic model.

Basic economic variables include: GDP at market exchange rates (**GDP**), GDP at purchasing power parity (**GDPP**), GDP per capita at market exchange rates (**GDPPC**), and GDP per capita at purchasing power parity (**GDPPCP**). The model represents all of these in constant 2011 dollars (the interface allows the user to convert to other currencies). The model also includes a representation of the portion of the economy that is informal.

Multifactor Productivity

The supply side of the economic module is based on the Cobb-Douglas Production Function and uses labor (**LAB**), capital (**KS**), and multifactor productivity (**MFP**) as the primary drivers of economic growth. Capital stock (**KS**) is a function of investment (**I**) and depreciation rates. Labor supply (**LAB**) is determined from population and endogenously derived labor force participation rates.

Variable Name	Description
GDP	Gross domestic product
GDPP	GDP at purchasing power parity
GDPPCP	Per capita GDP at purchasing power parity
GDPPC	Per capita GDP
LAB	Labor
KS	Capital stock
I	Investment
POPRETIRED	Retired population
MFP (HC,SC,PC,KN)	Multifactor productivity

While the treatment of capital and labor in the IFs system will be familiar to users with an understanding of neoclassical economics, the treatment of productivity within IFs deserves greater explanation. Unlike most neoclassical models, which primarily focus on technology as the determining factor of productivity in their equations, the IFs system uses a broader definition of productivity called multifactor productivity (MFP). This multi-factor productivity term in IFs has four basic components: human (**MFPHC**), social (**MFPSC**), physical (**MFPPC**), and knowledge capital productivity (**MFPKN**). Each of these components can take on a positive or negative value depending on whether the calculated value of the component is providing a positive or negative impact to economic growth rates relative to what would be expected based on the country's level of development. (See the Development Profile form in IFs to display the magnitude and direction of the four productivity elements.)

Drivers of multifactor productivity vary by component. **MFPHC** is driven by years of education, education expenditures, life expectancy and health expenditure. **MFPSC** is driven by Freedom House's measure of political

freedom (a variable describing democracy), governance effectiveness, corruption perceptions, and economic freedom. **MFPPC** is driven by two separate indices of infrastructure: traditional (roads, electricity, and water and sanitation), and information and communications technology (ICT). Finally, **MFPKN** is driven by R&D expenditures and economic integration (in the model, trade serves as a proxy for trade). This final component of MFP represents a measure of connectedness to the global economy. Altering any of these using the appropriate parameters will result in changes to the relevant component of multifactor productivity and therefore to economic growth.

The Social Accounting Matrix and Domestic Finance

Variable Name	Description
C	Private consumption
SAVINGS	Net national saving
HHINC	Household Income
HHSAV	Household savings
FIRMINC	Firm Income
FIRMSAV	Firm savings
IDS	Investment by destination sector
GOVREV	Government revenue
GOVEXP	Government expenditures
GOVHHTRN	Government household transfers
GOVCON	Government consumption
GDS	Government spending by destination
GOVBAL	Government balance
GOVDEBT	Government debt

The production function is embedded in a six sector model of the economy featuring agriculture, raw materials, energy, manufactures, services, and ICT that balances domestic demand and trade in a general equilibrium seeking structure. Production and consumption of goods and services are in turn incorporated into a larger social accounting matrix (SAM) which represents the behavior and financial interaction of households, firms and government. A social accounting matrix traditionally represents *flows* among different economic sectors and agent categories (i.e., households, firms, and government). For instance, it

represents private consumption (**C**) and net national savings (**SAVINGS**), as well as household income (**HHINC**) and savings (**HHSAV**); firm income (**FIRMINC**), investment by sector (**IDS**), and savings (**FIRMSAV**); government revenues (**GOVREV**), total expenditures with transfers (**GOVEXP**), transfers to households (**GOVHHTRN**), directed consumption in total (**GOVCON**), and by sector (**GDS**), and balance (**GOVBAL**). IFs builds a full and balanced social accounting matrix of these and many other inter-agent flows. It also creates a second matrix which represents financial *stocks* (assets and liabilities) of different agent categories for all countries in the system, including for instance, government debt (**GOVDEBT**). The representation of stocks in this fashion provides the foundation upon which the system adjusts flows of finance among different agents and among countries over time (see, for instance, the net foreign debt or **XDEBT** of countries), maintaining consistency with the liability-asset approach used in standard accounting systems. The behavior of agents within this system is not fixed, like it is in many computable general equilibrium models (which use SAMs commonly). Instead, agent behavior is partially endogenized using algorithms that allow the behavior of agents to shift depending on the levels of stocks of relevant variables within the SAM. So, for example, different levels of government debt trigger different patterns of government spending in IFs.

Because of its centrality to the IFs system, users should understand the basic character of the social accounting matrix. Both the stock and flow matrices are available in the specialized displays menu in the display section of the main menu. The social accounting matrix loads the flow matrix by default, but the stock matrix can be accessed via

the Show Stocks button on the bar at the top. Full breakouts of the SAM into its component parts is also available on this screen by clicking the button Expand SAM on the same top bar.

International Trade and Finance

Variable Name	Description
CURACT	Current account balance
CAPACT	Capital account
TRADEBAL	Trade balance
XWORKREMIT	Worker remittances from abroad
AID	Net foreign aid receipts
X or XS	Exports and exports by sector
M or MS	Imports and Imports by sector
ENX/ENM	Energy exports/imports
AGX/AGM	Agricultural exports/imports
XFDIFIN	Inward flow of FDI
XFDIFOUT	Outward flow of FDI
XFDISTOCK	Inward stocks of FDI
XFDISTOUT	Outward stocks of FDI
XPORTFIN	Inward flows of portfolio investment
XPORTFOUT	Outward flows of portfolio investment
XPORTFOLIO	Inward stocks of portfolio investment
XPORTSTOUT	Outward stocks of portfolio investment
XDEBTRPA	External debt, relative price adjusted
EXRATE	Exchange rate

The international financial position of a country is typically represented by the balance of payments, which is equal to zero if all flows of goods and finance into and out of a country are included. The balance of payments is determined by the status of three indicators, the current account (**CURACT**), the capital account (**CAPACT**), and the foreign reserve account (not explicitly modeled in IFs). Imbalances can exist in any of these if imports of goods and services outweigh exports for example, or if governments spend down foreign reserves.

In IFs, the status of the current account balance (**CURACT**), which reflects the many flows into and out of a country, is a function of the trade balance (**TRADEBAL**), net foreign worker remittances (**XWORKREMIT**), net foreign aid (**AID**), and net interest on foreign debt. Worker remittances are calculated on the basis of the size of the population of a country that is living and working abroad.

Of these the trade balance and treatment of trade within IFs more generally is worth further discussion. Trade in the IFs system is part of the social accounting matrix structure and is modeled using a pooled rather than bilateral approach. This means that IFs tracks information on gross exports and imports of countries by sector and in total. An algorithm sums price-adjusted import demand and export capacity across all countries that trade in a given sector and defines world trade as the average of those two values. Demand and capacity are then normalized to the total of world trade to determine total and sectoral exports (**X** or **XS by** sector) and imports (**M** or **MS** by sector) by country. As already noted, the agricultural and energy modules each represent production, consumption and trade that supersede the results of the economic module's production function and SAM. For instance, exports and imports in these modules are represented separately within the IFs system via **ENX/ENM** and **AGX/AGM**.

Interacting with the current account is the capital account (**CAPACT**). It captures the flows of foreign direct and portfolio investment into (**XFDIFIN** and **XPORTFIN**) and out of countries (**XFDIFOUT** and **XPORTFOUT**). The system also represents the stocks of inward and outward FDI and portfolio investment (**XFDISTOCK/ XPORTFOLIO** and **XFDISTOUT/XPORTOUT**). Together the current and capital account flows shape the stock of relative-price-adjusted

net foreign indebtedness (**XDEBTRPA**), which in turn via an equilibration process changes the exchange rate (**EXRATE**). The exchange rate, in interaction with local relative prices, affects trade and financial flows over time as a key part of that equilibration process.

Informal Economy

The economic module represents the informal economy as the share of the total labor force employed informally (**LABINFORMSHR**), the share of total GDP generated by informal activities (**GDPINFORMSHR**), and the share of total GDP generated by the shadow economy (**GDPSHADOWSHR**). The informal labor share is driven by four main variables: the educational attainment of adults 15 years of age and older (**EDYSAG15**, see the education model for parameters to affect this variable), the government business index (**GOVBUSREGIND**), the ratio of government transfers to households as a portion of GDP (**GOVHHTRN**), and the tax rate on firms (**FIRMTAXR**).

Variable Name	Description
LABINFORMSHR	Informal share of the labor force
LABINFORMPCNTINF	Portion of informal labor employed inside informal sector
LABINFORMPCNTNONINF	Portion of informal labor employed outside the informal sector (in formal enterprises or households)
GDPINFORMSHR	Informal share of GDP
GDPSHADOWSHR	Shadow economy share of GDP
EDYRSAG15	Educational attainment of adults 15 and older
GOVBUSREGIND	Government business regulation index (higher is better)
GOVCORRUPT	Government corruption (higher is less corrupt)
GOVHHTRN	Government transfers to households for welfare and pensions
GDS, R&D	Government spending on research and development
FIRMTAXR	Tax rate (direct) on firms
HHTAXR	Tax rate (direct) on households
SSWELTAXR	Tax rate (direct) on households and firms for social welfare
RANDDEXP	Total (public and private) spending on research and development
TEFF	Stock of total (multifactor)productivity

The informal labor share is divided into two sectors, the portion of informal labor employed inside the informal sector (**LABINFORMPCNTINF**, informal) and the portion of informal labor employed in the formal sector (represented by a simple residual **LABINFORMPCNTNONINF**).

Each sector is further divided by sex.

The share of informal labor in total labor and the portion of informal labor employed inside the informal sector both help drive informal and shadow GDP shares. Other drivers include the level of corruption (**GOVCORRUPT**), public expenditure on research and development as a percentage of its GDP (**GDS, R&D**), and total (public and private) spending on research and development (**RANDDEXP).**

While informal *and* shadow GDP shares are initialized in the Base Case, *only* informal (**GDPINFORMSHR**) has active forward linkages. To drive the forward linkages with the shadow economy share instead, you must change the switch, **gdpshadowon**, from its default, Base Case setting of 0 to 1 (see Parameters for Affecting the Informal Economy section below).

The informal GDP shares, in turn, have forward linkages to total or multifactor productivity (**TEFF**), effective household (**HHTAXR**) and firm tax rates, as well as to the effective rate for social welfare (**SSWELTAXR**).

Parameters to Affect Production and Growth

Parameter	Variable of Interest	Description	Type
Labor			
labparm	LAB	Labor participation rate multiplier	Multiplier
labfemshrm	FEMSHRLAB	Female labor force participation rate multiplier	Multiplier
labretagem	LAB	Retirement age, labor force participation multiplier	Multiplier
labunemprm	LABUNEMPR	Labor unemployment rate multiplier	Multiplier
labmarketsw	LABS	Labor demand to economic production switch (1=on)	Switch
labdemsm	LABDEMS	Labor force demand by sector multiplier	Multiplier
labcoeffsm	LABCOEFFS	Labor demand, multiplier on technology coefficients	Multiplier
<u>**workageentry**</u>	POPRETIRED	Age at which individuals enter the labor force	Exogenous specification
<u>**workageretire**</u>	POPRETIRED	Age at which individuals leave the labor force	Exogenous specification
Capital			
invm	IDS	Multiplier on all types of investments	Multiplier
Productivity			
mfpadd	MFP components	Multifactor productivity, additive	Additive factor
mfpleadr	MFP	MFP growth rate of the technological lead country	Growth Rate
mfpedspn	GDS-educ	Elasticity of multifactor productivity to education spending	Elasticity
malnelimstartyr	MALNPOPP	Undernourishment elimination start year	Standard error target
malnelimtargetyr	MALNPOPP	Undernourishment elimination target year	Standard error target
malelimprecisesw	MALNPOPP	Undernourishment elimination	Switch
ylm	YL	Agricultural yield	Multiplier
aginvm	INAG and IDS	Investment in agriculture	Multiplier
econfreem	ECONFREE	Economic freedom	Multiplier
goveffectm	GOVEFFECT	Government effectiveness	Multiplier
govcorruptm	GOVCORRUPT	Government corruption	Multiplier
freedomm	FREEDOM	Freedom/democracy	Multiplier
mfpinfrindtrad	MFPPC	Elasticity of multifactor productivity to traditional infrastructure index	Elasticity
mfpinfrindict	MFPPC	Elasticity of multifactor productivity to ICT infrastructure	Elasticity

mfpenpri	WEP	Elasticity of multifactor productivity with energy prices	Elasticity
gdsm, R&D	GDS, R&D	Government expenditures towards R & D	Multiplier

Based upon the discussion of key variables, the areas of likely interest to users are clear: parameters that affect production and growth most directly, parameters that affect domestic finance (including government) and the flows of the social accounting system, and parameters that affect trade and finance. We start with production and growth and the key parameters affect labor, capital and multifactor productivity. Parameters exist in the IFs system that allows users to modify any of the component parts of the Cobb Douglas Production function. Parameters affecting labor supply include **labparm, labfemshrm,** and **labretagem**. The first of these, **labparm** modifies the labor force participation rate, while the second changes the female share of the existing labor force, and the last, **labretagem,** changes the number of retired persons who participate in the labor market. Other parameters, discussed in the demographic section, also impact the size of the labor force. The parameters **workageentry** and **workageretire**, will change when people enter and leave the labor force, thus altering the length of time they are employed and the size of the labor pool. In addition to these, the user can influence the unemployment rate in the population through the multiplier **labunemprm.** The activation of the switch **labmarketsw** allows a user to observe the impact of changes in labor demand on production.

For the demand side of labor, the parameter **labcoeffsm** helps a user influence the labor demand co-effciients by sector and skill level (which are measured in terms of millions of people per dollar). The multiplier **labdemsm** influences total labor demand by sector and skill level.

The labor market demand and supply equilibrate on the basis of the variable **LABWAGEIND.** This equilibration occurs through four co-efficients that equilibrate demand and supply and demand through a PID (Proportional, Integral and Differential) formulation. **ellabwage1** and **ellabwage2** equilibrate demand and supply for labor while **elwageunemp1** and **elwageunemp2** account for the impact of unemployment on the equilibration.

Users can affect capital accumulation by changing the parameter **invm**, which alters investment in the economy using a multiplicative approach. Unlike spending multipliers discussed later under Domestic Finance, this multiplier cannot be broken out by destination. It will also affect savings because domestic savings rates are directly tied to investment rates. In addition to altering savings, investment rate changes affect the rate of capital accumulation.

Two brute force multipliers on productivity are available to users. First, **mfpadd** allows users to increase productivity growth in an additive manner on a country-by-country basis. Second, the parameter **mfpleadr** allows users to set the growth rate of the world's technological leader, the United States. Since all other country's productivity is tied to the leader, changes to this parameter model assumptions about global economic growth rates, which will tend to change productivity growth rates across a number of countries. Although both these parameters represent powerful ways to affect GDP and growth, users should note that they do not carry a cost. Like other brute force multipliers, there is no cost accounting system that might limit the impact of changes introduced, so users must be extremely careful to justify any changes made with these parameters.

Users can change any one of the components of multifactor productivity by affecting the drivers of the component. Any of the parameters that impact life expectancy, education levels, or health and education spending, as discussed in the health or education modules, will impact MFPHC. Examples include but are not limited to: **mfpedspn**, **ylm**, and **aginvm.**

Similarly, anything that affects drivers of social capital will affect MFPSC. These include many of the governance parameters, such as: **econfreem, goveffectm, govcorruptm,** and **freedomm.**

Physical capital is primarily impacted by two indices of physical [infrastructure](#) development, one for traditional infrastructure, which includes electricity, transportation, and water and sanitation, and a separate index for ICT. Users can affect the elasticity of MFP to these indices using **mfpinfrindtrad**, and **mfpinfrindict**. By changing these parameters users can make the value of MFPPC more or less responsive to the speed of growth in the two areas of infrastructure discussed above. They can also alter the elasticity of MFP to the world energy prices using **mfpenpri**, which performs a similar function for changing the relationship of MFPPC to energy prices globally. See the discussion of the infrastructure module to see the large number of parameters that affect the specific elements of the two general infrastructure indices.

Knowledge capital will respond to changes in the parameter **gdsm,** targeted at changing the amount of government spending directed towards research and development. It will also respond to the level of trade interconnectedness, which the level of protectionism (**protecm**) can affect—to be discussed again below.

Parameters to Affect Domestic Financial Flows and the Social Accounting System

Parameter	Variable of Interest	Description	Type
govrevm	GOVREV	Government revenue multiplier	Multiplier
gdsm	GDS	Government spending by destination sector	Multiplier
gdsedm	GDS	Education spending distribution multiplier	Multiplier
govhhtrnpenm	GOVHHTRN	Government pension spending multiplier	Multiplier
firmtaxrm,	SAVINGS	National tax rates on firms	Multiplier
hhtaxrm (skilled, unskilled)	SAVINGS	National tax rates on households, broken down by skilled and unskilled	Multiplier
indirecttaxrm	SAVINGS	Social security and welfare tax multiplier (indirect taxes)	Multiplier
ginidomr	GINIDOM	Domestic Gini Index growth rate	Growth Rate
ginidomm	GINIDOM	Domestic Gini Index multiplier	Multiplier
gdprext	GDP	GDP growth rate exogenous target; works with gdadjsw	Growth Rate

The leverage points within the area of domestic financial flows and the social accounting matrix of greatest interest for most analyses and government revenues and expenditures. The brute force multiplier on government revenues (**govrevm**) will increase or decrease those and have wide secondary effects as processes play out to adjust revenue raising and expenditure patterns to the new level. On the outflow side, the government spending by destination multiplier (**gdsm**) will change patterns of government consumption using a multiplier that acts on military, health, education, R&D, infrastructure, other infrastructure, and other (the residual). Education spending can also be modified using **gdsedm,** which directly modifies spending on education by level (as discussed in the [education module](#)). Unless total government consumption (**GOVON**) is altered, however, changes in spending patterns by target will create shifts from one category to another rather than changes in the total, because the model will normalize the sum of spending by sector to that total. Similarly, the user can use multipliers on government pension (**govhhtrnpenm**) spending to change levels in either of those categories, but subject along with direct consumption expenditure to the constraint of total government expenditures (**GOVEXP**). Hence, parameters that affect government revenues are very important.

Changes in the tax rates can have profound implications for government capacity, and for this reason IFs contains a number of parameters to alter taxation rates for different actors, in addition to the direct multiplier on government revenues, which will cause the model to endogenously adjust such tax rates. Of these, three stand out. **Hhtaxrm** affects household savings rates, **firmtaxrm** modifies firm taxation rates, and **indirecttaxrm** changes the indirect taxation rate on goods and services. The household taxation rate multiplier is subdivided according to whether households are skilled or unskilled. Users who are interested in scenarios that change domestic income inequality may want to change **ginidomr**, which alters the ratio of the domestic Gini (**GINIDOM**) to the initial condition. Domestic Gini (**GINIDOM**) can also be altered using the parameter **ginidomm**, which acts as a multiplier on the calculated value of **GINIDOM** in the model. Finally, **gdprext** offers users a power way to speed up, or slow down, total GDP growth.

Parameters to Affect Trade and International Finance

Parameter	Variable of Interest	Description	Type
xshift	X, XS	Export shift as a result of trade promotion	Additive factor
protecm	M, MS	Protectionism in trade, multiplier on import prices	Multiplier
termtrm	TERMTR	Terms of trade balance, higher favors global south	Multiplier
xfdistockm	XFDISTOCK	Inward stocks of FDI multiplier	Multiplier
xfdistoutm	XFDISTOUT	Outward stocks FDI multiplier	Multiplier
xfdiwgrm	XFDISTOCK, XFDIOUT	World FDI growth rate multiplier	Multiplier
xportfoliom	XPORTFOLIO, XPORTFIN	Inward portfolio investment multiplier	Multiplier
xportstoutm	XPORTFOLIO	Outward portfolio investment stock multiplier	Multiplier
aiddon	AID	Aid foreign loan donations as % GDP	Additive factor
aidrecm	AID	Aid receipts as % GDP	Multiplier
aidlpm	AID, AIDLP	Aid foreign loan percentage multiplier	Multiplier

Users can alter imports and exports via two major channels. First, they can force a shift towards export promotion using the additive **xshift** parameter. Increasing the parameter value to .05 would result in an additional 5% being added to the value of exports for that year and all subsequent years until the dynamics of the model dampen the effect. Protectionism in imports can be modeled by changing the value of **protecm**, which is a multiplicative parameter that increases the cost of imports and thereby proxies an increase in tariff rates or of non-tariff barriers to trade.

Finally the distribution of the global terms of trade can be impacted by **termtrm**. Raising this multiplicative parameter will alter the balance of global trade patterns to favor southern developing countries (colloquially known as the Global South). This means that an increase in this parameter will increase the financial value of the exports from these developing nations, while reducing the relative financial value of exports from developed nations.

Affecting global financial flows is a relatively complex process in the IFs economic system. Multiple channels exist to modify the different major sources of international financial flows. Users can alter foreign direct investment flows using the **xfdistockm** parameter, which increases the stocks of FDI within a country and adjusts flows

accordingly. Conversely, **xfdistoutm** will increase the size of the stock of FDI slated to exit a country. Users may also wish to alter the growth rate for FDI at a global level via the parameter **xfdiwgrm**.

Portfolio investment can be modified using a similar set of parameters. **Xportfoliom** allows users to increase the stocks of portfolio investment within a country, while **xportstout** controls the amount of portfolio investment that a country's citizens hold abroad.

Aid parameters differ somewhat from those available for FDI and portfolio investment. Users can change the amount of foreign loan donations as a percent of GDP via **aiddon**, which specifies the portion of donor country GDP given in the form of aid. They may change the amount of aid a country receives using the **aidrecm** parameter, which determine the portion of the global aid pool created by donors that any individual country will receive (the total claims on that pool determined by **aidrecm** will be normalized to the total size of the pool). Finally, users may alter the portion of aid that comes in the form of loans that accrue interest and must be repaid within a certain time frame using the multiplicative parameter **aidlpm**.

Parameters to Affect the Informal Economy

Parameter	Variable of Interest	Description	Type
labinformshrm	LABINFORMSHR	Informal labor force share multiplier	Multiplier
gdpinformshrm	GDPINFORMSHR	Informal GDP share multiplier	Multiplier
gdpshadowshrm	GDPSHADOWSHR	Shadow economy GDP share multiplier	Multiplier
gdpshadowon	GDPSHADOWSHR	Switch to turn on GDPSHADOWSHR instead of GDPINFORMSHR. Default is 0 (GDPINFORMSHR). 1 turns on GDPSHADOWSHR instead.	Switch
edyrsagm	EDYRSAG15	Years of education ages 15 and up multiplier	Multiplier
firmtaxrm	FIRMTAX	Tax rate on firm's multiplier	Multiplier
gdsm	GDS	Government R&D (and education) spending distribution multiplier	Multiplier
govbusregindm	GOVBUSREGIND	Government business regulation index multiplier	Multiplier
govcorruptm	GOVCORRUPT	Government corruption multiplier	Multiplier
govhhtrnpenm	GOVHHTRN	Government pension spending multiplier	Multiplier
govhhtrnwelm	GOVHHTRN	Government welfare spending multiplier	Multiplier
randdexpm	RANDEXP	Total (public and private) expenditure on research and development multiplier	Multiplier
taxinfadjm	HHTAXR, FIRMTAXR, SSWELTAXR	Multiplier of impact of informal GDP share on tax rates	Multiplier
labinformcoeffbus	LABINFORMSHR	Informal labor share, coefficient of business index	Coefficient
labinformcoeffed	LABINFORMSHR	Informal labor share, coefficient of education years	Coefficient
labinformcoeffhhtrn	LABINFORMSHR	Informal labor share, coefficient of household transfers	Coefficient
labinformcoefftax	LABINFORMSHR	Informal labor share, coefficient of tax rate	Coefficient
gdpinformcoeffcorrupt	GDPINFORMSHR	Informal GDP share, coefficient of government corruption	Coefficient
gdpinformcoeffintercept	GDPINFORMSHR	Informal GDP share, intercept of model	Coefficient
gdpinformcoefflabinf	GDPINFORMSHR	Informal GDP share, coefficient of informal labor share	Coefficient
gdpinformcoeffrandd	GDPINFORMSHR	Informal GDP share, coefficient of R&D spending	Coefficient
gdpshadowcoeffintercept	GDPSHADOWSHR	Shadow economy GDP share, intercept of model	Coefficient
gdpshadowcoefflabinf	GDPSHADOWSHR	Shadow economy GDP share, coefficient of informal labor share	Coefficient
gdpshadowcoeffcorrupt	GDPSHADOWSHR	Shadow economy GDP share, coefficient of government corruption	Coefficient
gdpshadowcoeffrandd	GDPSHADOWSHR	Shadow economy GDP share, coefficient of R&D spending	Coefficient

Users can affect the labor informal share of the total labor force directly (**labinformshrm**). In most cases they will do so indirectly by affecting the driving variables of that share. One of the driving variables is educational

attainment of adults, so any parameter affecting that attainment will have a potential impact (see the parameters for education including the prepackaged scenarios). Another is the government business index (**govbusregindm**). A third is government to household transfers for either pensions or welfare (**govhhtrnpenm** and **govhhtrnwelm**). A fourth is the tax rate on firms (**firmtaxm**).

The forward linkage from informal labor share to informal GDP share is affected by a multiplier (**gdpinformshrm**) that can totally turn off that linkage if set to 0. The informal GDP share can be directly affected via **gdpinformshrm**, or indirectly by affecting its drivers, including informal labor share. Other drivers include: the level of government corruption (**govcorruptm**), government spending on research and development (gdsm, R&D) and total (public and private) spending on research and development (**randdexpm**). Manipulating **randdexpm** itself will increase private sector spending while changing **gdsm** will also impact the public portion of **RANDDEXP**.

A set of parameters (**labinformcoeffbus, labinformcoeffed, labinformcoeffhhtrn, labinformcoefftax**) control the calculation of informal labor share from its assorted drivers.

A similar set of parameters (**gdpinformcoeffintercept**, **gdpinformcoeffcorrupt**, **gdpinformcoefflabinf**, **gdpinformcoeffRandD**) control the calculation of informal GDP from its assorted drivers.

The model includes the shadow economy share of GDP (**GDPSHADOWSHR**) as an additional measure of informality in the economy. Under the Base Case, **GDPSHADOWSHR** is initialized but does not have active forward linkages (the Base Case drives all informality-related forward linkages with GDPINFORMSHR instead). The shadow economy GDP share can be affected directly by changing **gdpshardowshrm** or indirectly by changing its drivers, which as with the informal economy share, are: informal labor, government corruption, and spending on R&D. The shadow economy uses a similar set of parameters to the informal economy (**gdpshadowcoeffintercept**, **gdpshadowcoeffcorrupt**, **gdpshadowcoefflabinf**, **gdpshadowcoeffRandD**) to control the calculation of the shadow economy from its drivers.

Users wanting to drive the forward linkages from informality with the shadow economy instead of the informal economy can do so by changing the switch **gdpshadowon** from its default, Base Case setting of 0 (which tells the model to drive the forward linkages with **GDPINFORMSHR**) to 1 (which tells the model to drive them with **GDPSHADOWSHR** instead).

The informal and shadow GDP shares (whichever is activated—see above) use the same multipliers for their linkages to multifactor productivity (**tefinfadjm**) and tax rate (**taxinfadjm**)**.**

Prepackaged Scenarios

A large number of prepackaged scenarios that revolve around economic development and poverty alleviation are available for user access, located under the PPHP Poverty heading in the World Integrated Scenario Sets. The best and worst case Framing Scenarios include changes to the growth in MFP for the world leader, the additive growth rate factor for MFP, TFR, and the Gini index.

More integrated scenario sets are available as well to model the effects of combinations of interventions. These are labeled Combined Dom Intl Interventions (Rev, Rev2). This scenario is built from two different series of interventions: Leverage Testing Intl, and Leverage Testing Domestic, which user can explore if they wish to look more closely at individual interventions from the combined scenario. Users should also use these scenarios and the Combined Dom Intl Interventions (Rev, Rev2) to get a sense of how to scale interventions to different regions of the world or even globally, rather than altering a single country at a time.

Revision 2 models a number of parameter changes including: growth in multifactor productivity (**mfpadd**), declines in TFR (**tfrm**), increases in the female share of the labor force(**labfemshrm**) and world migration(**wmigrm**), increases in investment (**invm**), foreign aid, FDI and portfolio investment (**xfdistockm** and **xportfoliom**), declines in

protectionism and resulting increase in exports (**protecm** and **xshift**), increased government expenditures on education, health, and R&D (**gdsm**), greater welfare transfers to unskilled labor(**govhhtrnwelm**), improvements to governance (declines in corruption-**govcorruptm**, increases in effectiveness- **goveffectm**, and economic freedom-**econfreem**), improved infrastructure in roads, ICT, and telephone network density (**infranetm**, **infraroadm**,**infratelem**), and increased energy production from renewable resources (**enpm**).

Of these, the economic changes deserve special attention. This scenario includes an improvement in multifactor productivity in the World Bank developing economies to 0.002 over a ten year time horizon, growth in the female share of the labor force to 1.5 time the base case over a 50 year time frame and increases in world migration multiplier to 1.5 over a 15 year time frame. It also increases investment multiplier to between 1.3 and 2 over a 15 to 25 year time frame depending on the region triggering increased capital accumulation and savings.

Government expenditure is also affected. Expenditure to education increases to between 1.2 and 1.8 times the base case implemented over ten years. Expenditure to health and research and development also increase by similar amounts over approximately the same time frame. Government to household transfers increase in different regions by 50 to 100% (multiplier values of 1.5 to 2) over a 20-year time frame. Trade and export promotion increase as well. Levels of protectionism decline by 20% over 20 years (a multiplier value of .8) and the ratio of exports to imports grows by .04.

And finally, FDI and portfolio investment are affected. FDI doubles over 25 years in the World Bank developing economies while portfolio investment increases by 50% over the same time frame. Foreign aid by donor nations increases to .5% of GDP over ten years. There are also increases in the availability of IMF funding that go beyond the scope of this guide, but which may be of interest to specialists in international finance.

With respect to the informal economy, eight scenarios have been developed for Peru. Six of them each manipulate one of the drivers of either informal labor or informal GDP share. In each case an "aggressive but reasonable" value of the driver works to reduce informality. The other two involve more general impacts on information. The first (Comb Lab GDP 1.5 drivers.sce) combines all of the six individual drivers into a single scenario to reduce informality. The second or counterfactual scenario (Informal GDP Share Total Decline Peru 15 years.sce) use a brute force multiplier on the informal GDP share to reduce it to the minimum value allowed (1 percent) between 2016 and 2030.

Infrastructure Module

Variables of Interest

The Infrastructure module in the IFs system forecasts infrastructure development and its consequences via a five stage process that is driven primarily by the expected/demanded levels of infrastructure and the funding available to meet these expectations or demands.

The model first estimates the expected/demanded level of infrastructure within a country in relation to key drivers like GDP per capita and population.[4] Second, it translates these expectations into financial requirements, accounting for both new construction and maintenance. Third, the system balances these desired funding levels with the actual resources available for infrastructure construction and maintenance. Fourth, it forecasts the actual attained levels of infrastructure (both in raw physical terms and in terms of population access rates). Fifth, these levels of infrastructure have specific and direct social, economic and environmental impacts related to these attained levels (processes discussed in connection with other modules).

The distinction between expected and demanded levels of infrastructure is a function of the scenario being modeled. In general scenarios, e.g., the Base Case, we use the term expected because the underlying equations are based on historical data reflecting both underlying demands and supply constraints. In scenarios with targets, however, these equations are overridden by equations reflecting the target path, when the expected values lag behind the values defined by the target path. In such instances, therefore, we are more clearly identifying demands for infrastructure, rather than expectations.

Infrastructure variables can be divided into three major types: physical infrastructure, access, and funding.[5] Road density, percentage of road paved, electricity generation capacity, and the amount of land equipped for irrigation all represent key physical infrastructure variables that indicate actual infrastructure stocks within a country. Key access variables, which indicate the degree to which people are able to benefit from existing infrastructure, include: rural population living within 2 kilometers of an all-season road (the road access index); population with access to electricity; reliance on solid fuels for energy; population with access to improved safe water, sanitation, and wastewater treatment; and subscriptions per 100 people to fixed line telephones, mobile phones, and fixed or mobile broadband.

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[4] This calculation treats physical stocks differently from access indicators depending on the type of infrastructure being considered. For roads, expected access is calculated as a function of the physical stocks, while for electricity, water and sanitation, and ICT, physical stocks are calculated on the basis of the expected levels of access. This has implications for the functioning of the parameters discussed below.

[5] IFs also distinguishes between 'core' and 'other' infrastructure. Core infrastructure refers to those types of infrastructure that we represent explicitly in IFs—roads, electricity generation, improved water and sanitation, and ICT. Other infrastructure refers to those types that we do not represent explicitly—e.g., railroads, ports, airports, and future types of infrastructure yet to be envisioned. Please note that although we do not represent these other forms of infrastructure explicitly, we do estimate spending on them in order to avoid under-representing the total demand for infrastructure. The choice of what to include as core infrastructure reflects the availability of historical data and our determination of what can be modelled within IFs at this time.

Physical Infrastructure

Key physical Infrastructure variables for transportation are **INFRAROAD**, and **INFRAROADPAVEDPCNT**. The variable **INFRAROAD** represents a measure of total road density (paved and unpaved), while the variable **INFRAROADPAVEDPCNT** offers a measure of the quality of the transportation infrastructure within a country using paved percentage as a proxy.

Key variables for electricity are the amount of electricity generation capacity within a country, denoted by **INFRAELECGENCAP** and

Variable Name	Description
Transportation	
INFRAROAD*	Total road density
INFRAROADPAVEDPCNT*	Percentage of roads paved
Electricity	
INFRAELECGENCAP*	Electricity generation capacity per capita
INFRAELECTRANSLOSS	Electricity transmission loss
INFRAELECADJFACT	Electricity adjustment factor
ENELECSHRENDEM	Ratio of electricity use to total primary energy use
Water and Sanitation	
LANDIRAREAEQUIP	Area equipped with irrigation
*each variable marked with an asterisk has a companion variable with the suffix DEM, which indicates the expected/demanded level of the variable in the absence of funding constraints	

expressed in kilowatts per person. Other variables, which represent quality indicators, are **INFRAELECTRANSLOSS**—the transmission and distribution loss in percent—and **INFRAELECADJFACT**—the capacity factor for electricity production, expressed as a fraction, and **ENELECSHRENDEM**, the ratio of electricity use to total primary energy use. It is also possible to calculate electricity connections using the results on access to electricity, discussed below, and population.

The only physical infrastructure variable for water and sanitation is the area equipped for irrigation, **LANDIRAREAEQUIP**, which represents the amount of land in thousands of hectares that is equipped with irrigation. There are no key physical infrastructure variables associated with ICT, only access rates. Users wishing to affect ICT infrastructure should modify access, which, along with population, can be used to calculate actual physical infrastructure levels.

Access to Infrastructure

Variable Name	Subcategories	Description
Transportation		
INFRAROADRAI*		Access to rural roads
Electricity		
INFRAELECACC*	Rural, urban, total	Access to electricity
ENSOLFUEL		Solid fuel use
Water and Sanitation		
WATSAFE*	None, other improved, piped	Access to improved water
SANITATION*	Other unimproved, shared, improved	Access to improved sanitation
WATWASTE		Access to wastewater collection
WATWASTETREAT*		Access to wastewater treatment
ICT		
INFRATELE*		Fixed telephone lines

ICTBROAD*	Fixed broadband subscriptions
ICTMOBIL*	Mobile telephone subscriptions
ICTBROADMOBIL*	Mobile broadband subscriptions

*each variable marked with an asterisk has a companion variable with the suffix DEM, which indicates the expected/demanded level of the variable in the absence of funding constraints. Please see the note below for a more comprehensive description of the difference[6]

Physical infrastructure may be essential, but unless people have access to it, they cannot benefit. Because of this, access variables are included wherever possible in the IFs system. Transportation contains only one key access variable. This variable, **INFRAROADRAI**, provides a measure of degree of access people have to the existing road infrastructure. It is defined as the percent of the rural population living within 2km of an all season road.

INFRAELECACC provides a measure of access to electricity, disaggregated by rural and urban users. Another measure of access to electricity that users may be interested in from a health perspective is **ENSOLFUEL** which represents the percentage of the population relying on solid fuels for energy, and a significant factor in both environmental change and certain health conditions.

The two fundamental access variables of interest for water and sanitation are **WATSAFE** and **SANITATION**, which measure the percentage of the population with access to improved water sources and sanitation, respectively, by type of access. Water access is subdivided into unimproved, other improved, and piped. Sanitation access is subdivided into other unimproved, shared, and improved (note that shared access is not considered improved). **WATWASTE** and **WATWASTETREAT** represent the percentage of the population whose wastewater is collected and treated, respectively.

Four ICT variables represent access to the major components of information and communication technologies. **INFRATELE** represents the number of fixed line telephones per 100 people while the other three indicators, **ICTBROAD**, **ICTMOBIL**, and **ICTBROADMOBIL**, provide the number of subscriptions per 100 people for fixed broadband, mobile telephones, and mobile broadband, respectively. The dynamics of the model are structured in such a way that the long term trend is for fixed line telephones to decline, while use of mobile and mobile broadband increases.

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[6] The vast majority of Infrastructure variables have both a standard variable, representing the actual achieved level of infrastructure stock or access, and a demand/expectations related variable suffixed by *DEM. The interpretation of the *DEM variables should change subtly depending on the analytical context. When discussing the Base Case or when applying any of the multiplicative parameters, it is more useful to think of the *DEM variables as expected levels; when building scenarios that manipulate the ***setar/*seyrtar** parameters, it is more accurate to think of them as demand variables.

Infrastructure Funding

Variable Name	Description
GDS (infrastructure, infraother)	Government consumption, by category
INFRAINVESTMAINT	Total (public plus private) investment for core infrastructure maintenance, by type of infrastructure
INFRAINVESTMAINTPUB*	Public investment for core infrastructure maintenance, by type of infrastructure
INFRAINVESTNEW	Total (public plus private) investment for construction of new core infrastructure, by type of infrastructure
INFRAINVESTNEWPUB*	Public investment for construction of new core infrastructure, by type of infrastructure

* The companion variables, **INFRABUDDEMMNT** and **INFRABUDDEMNEW**, are the amounts of public spending originally requested prior to the government budget allocation process

The infrastructure module in IFs incorporates a cost accounting system that ensures that all infrastructure improvements are funded prior to construction, which allows for a gap between the amount of infrastructure that is expected/demanded and the amount that is actually achieved.

As in other modules, GDS provides a good overview of total public spending on infrastructure, but this cannot be broken down by type of infrastructure any more specifically than core infrastructure and other infrastructure. **INFRAINVESTMAINT** provides the measure of the total investment for infrastructure maintenance, while **INFRAINVESTMAINTPUB** provides infrastructure investment for maintenance provided by public sector funds. **INFRAINVESTNEW** provides an indicator of the total spending on construction of new infrastructure, while **INFRAINVESTNEWPUB** provides the spending that came from public sources for the purposes of new investment. For the purposes of parameter manipulation, we will discuss the types of infrastructure separately because their dynamics vary widely with regards to how the model calculates physical infrastructure versus access. Absolute and relative target parameters to affect infrastructure access are discussed together because all share similarities in terms of structure and function within the model. Finally, there is some discussion of how to combine the two different types of parameters. These variables are subdivided based on whether the spending is for maintenance purposes or for the building of new infrastructure, and whether funding comes from public or private sources. Private funding is related to public funding in some ratio in all cases but ICT, where private funding has historically been the driver of infrastructure investment.

The two public spending variables, **INFRAINVESTMAINTPUB** and **INFRAINVESTNEWPUB**, have companion variables like many of the physical infrastructure and access variables discussed above. Specifically, the variables **INFRABUDDEMMNT** and **INFRABUDDEMNEW** represent the amounts of public spending originally requested prior to the government budget allocation process. When there are shortages, **INFRAINVESTMAINTPUB** and **INFRAINVESTNEWPUB** will be less than **INFRABUDDEMMNT** and **INFRABUDDEMNEW**.[7] In addition to producing a shortfall of public investment, this will also reduce private spending, except for the case of ICT infrastructure. The

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[7] It is also possible for **INFRAINVESTMAINTPUB** and **INFRAINVESTNEWPUB** to be less than **INFRABUDDEMMNT** and **INFRABUDDEMNEW** for another reason. This occurs when countries try to increase infrastructure spending more rapidly than is considered feasible. In this case, some of the funds allocated are held back and released over several years. Please refer to the technical documentation on the infrastructure model for more details on this process.

treatment of ICT differs because private funding has historically been the driver of investment in ICT infrastructure, whereas the public sector has been the driver of investment in other infrastructure.

Parameters to Affect Infrastructure

Four basic types of parameter are used in this module. They are, multiplicative parameters, technological shift factors, absolute, and relative targets. In general, multiplicative and technological shift factors operate in the same way; likewise, absolute and relative targets have similar functionalities.

There are some general rules that govern the interaction among the different types of parameters. [8] The first rule states that, if multiplicative or tech shift factor parameters are used in conjunction with absolute or relative targets, the multiplicative/technological shift parameters are applied first and then the relative or absolute targets are calculated. The second rule states that absolute and relative targets cannot be applied together. If they are, the model interprets this as an inconsistent application of parameters and will not implement either. The exception to both these rules are ICT fixed and mobile broadband, where the multipliers **ictbroadm** (for fixed broadband) and **ictbroadmobilm** (for mobile broadband), are applied after the absolute or relative target parameters are applied. Fixed broadband is also the exception to the rule that absolute and relative targets cannot be applied together. Instead they are both calculated within the model and then the larger of the two values is taken.

 In analyzing scenarios involving changes to the majority of the parameters described below, users should first check variables with the suffix DEM, where available, because many of the parameters modify expected/demanded levels of access. Assuming that the model has modified the expected/demanded level as desired, the user should next check the actual achieved levels of infrastructure. The reason is that if a parameter change increased the level of demand, but the impact did not raise demand above achieved levels otherwise computed in the model, there would likely be no apparent impact on the achieved level. For instance, users wishing to affect access to sanitation via **sanitationm** should first check **SANITATIONDEM** to examine the impact on expected/demanded levels, before checking **SANITATION** to determine the impact on the actual level fuels of access to sanitation within the population.

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[8] There are some exceptions to the rules laid out below, primarily as pertains to the treatment of fixed broadband within ICT.

Roads

Parameter	Variable of Interest	Description	Type
infraroadm	INFRAROAD	Multiplier on road density expected/demanded	Multiplier
infraroadpavedpcntm	INFRAROADPAVED PCNT	Multiplier on percentage of roads paved	Multiplier
infraroadraitrgtval, infraroadraitrgtyr	INFRAROADRAI	Target value/years after 2010 for achievement for population percentage living w/in 2km of an all-weather road	Absolute target
infraroadraisetar, infraroadraiseyrtar	INFRAROADRAI	Standard error target and years after 2010 for achievement for rural road access index	Relative target
Note: Using both *trgtval/trgtyr **and the** *setar/*seyrtar **parameters to affect the same outcome variable will block the impact of both, so users should be careful to only use one or the other of these types at a time, except in the case of fixed broadband, where the larger of the two effects will have an impact.**			

All the multiplicative parameters that users can use to affect roads affect physical infrastructure variables. This means that changes to **infraroadm** directly impact the variable **INFRAROAD**, which are in turn used to calculate the variable INFRAROADRAI, which is the infrastructure access variable for road infrastructure. Changes to **infraroadpavedpcntm** actually alter the percentage of roads in a country which are paved. There are no multiplicative parameters which directly affect road access.

To directly alter **INFRAROADRAI** users can use one or the other of the parameter combinations **infraroadraitrgtval/infraroadraitrgtyr** or **infraroadraisetar/infraroadraiseyrtar**. Either set will affect desired levels of access to road infrastructure. In the event that initially computed achieved road access levels do not meet the target value, the model will determine the levels of physical infrastructure stocks required to meet the desired levels of road access and will, subject to financial resource constraints, adjust they physical stocks so as to move the achieved access level to the target.

Electricity

Parameter	Variable of Interest	Description	Type
infraelecgencapm	INFRAELECGENCAP	Multiplier on electricity generation capacity per person	Multiplier
infraelecaccm	INFRAELECACC	Multiplier on electricity access	Multiplier
enelecshrendemm	ENELECSHRENDEM	Multiplier on ratio of electricity use to total primary energy use	Multiplier
infraelectranlossm	INFRAELECTRANLOSS	Multiplier on the loss of electricity in transmission and distribution	Multiplier
ensolfuelm	ENSOLFUEL	Multiplier on the reliance on solid fuel as a source of energy	Multiplier
infraelecacctrgtval/ infraelecacctrgtyr	INFRAELECACC	Target value and years after 2010 for target achievement for population percentage w/ access to electricity	Absolute target
infraelecaccsetar/ infraelecaccseyrtar	INFRAELECACC	Standard error target and years after 2010 for population percentage w/ access to electricity	Relative target

ensolfueltrgtval/ ensolfueltrgtyr	ENSOLFUEL	Target value and years after 2010 for target achievement for percentage of households reliant on solid fuels	Absolute target
ensolfuelsetar/ ensolfuelseyrtar	ENSOLFUEL	Standard error target and years after 2010 for target achievement for percentage of households reliant on solid fuels	Relative target

Note: Using both *trgtval/trgtyr **and the** *setar/*seyrtar **parameters to affect the same outcome variable will block the impact of both, so users should be careful to only use one or the other of these types at a time, except in the case of fixed broadband, where the larger of the two effects will have an impact.**

Electricity in the infrastructure model contains parameters that alter both physical infrastructure and access levels using multiplicative parameters. The parameter **infraelecgencapm** directly affects **INFRAELECGEN**, which represents the physical capacity to generate electricity and is a physical infrastructure variable.

Access to electricity, which is represented by **INFRAELECACC**, can be directly affected by **infraelecaccm**, a parameter that directly impacts access to electricity. This parameter is subdivided to allow users to affect urban and rural access separately.

Three other multiplicative parameters are relevant to discussion of electricity access in the infrastructure module. These are **ensolfuelm**, **enelecshrendemm,** and **infraelectranlossm**. **Ensolfuelm** changes solid fuel reliance as a primary energy source for domestic cooking and heating (ENSOLFUEL), which is also driven by **INFRAELECACC**. **Enelecshrendemm**, changes the ratio of electricity use to total primary energy use (this is a variable of relevance to the energy module, but is not yet linked to it). It allows users to change how reliant a country is on electricity relative to other sources of final energy use. It indirectly affects the expected/demanded amount of electricity generation capacity as represented by the variable **INFRAELECACCDEM**. **Infraelectranlossm** affects the loss of electricity during transmission and distribution. It is a parameter that allows users to affect the efficiency and quality of the electricity infrastructure. Like **enelecshrendemm**, this parameter indirectly affects **INFRAELECACCDEM**.

There are also target access parameters to allow users to set targets for desired levels of infrastructure access. These include **infraelecacctrgtval/infraelecacctrgtyr**, **infraelecaccsetar/infraelecaccseyrtar**, **ensolfueltrgtval/ensolfueltrgtyr**, and **ensolfuelsetar/ensolfuelseyrtar**. These set absolute and relative targets and target years for desired levels of electricity access and solid fuel use respectively.

Water and Sanitation

In IFs, water and sanitation sub-model comprises of two levels of disaggregation. The first one is an older 3-tier breakdown that categorizes water access into: (i) Unimproved, (ii) Other Improved and (iii) Piped and sanitation access into: (i) Improved, (ii) Other Unimproved and (iii) Shared.

The second one, reflects the new update from JMP (WHO-UNICEF) that categorizes water and sanitation into a 5-tier breakdown. In this new 5-tier system, water access is classified as (i) Surface, (ii) Unimproved, (iii) Limited, (iv) Basic and (v) Safely Managed and sanitation access is classified as (i) Open Defecation, (ii) Unimproved, (iii) Limited, (iv) Basic and (v) Safely Managed.

In order to default to the older 3-tier model, parameter switches namely, watsafenewsw and sanithhmodel2sw must be set to 0 before rebuilding the base. Alternatively, upon setting their values to 1 and rebuilding the base allows the user to switch to the newer 5-tier water and sanitation model. The first table below lists all relevant parameters associated with the 3-tier model while the second table lists all relevant parameters associated with the 5-tier model.

For the 3-tier model:

Parameter	Variable of Interest	Description	Type
watsafenewsw	N/A	Switch to activate 5-tier or 3-tier water model (0=3-tier model; 1=5-tier model)	Switch
sanithhmodel2sw	N/A	Switch to activate 5-tier or 3-tier sanitation model (0=3-tier model; 1=5-tier model)	Switch
landirareaequipm	LANDIRAREAEQUIP	Multiplier on land area equipped for irrigation	Multiplier
sanitationm	SANITATION	Multiplier on percentage of people with access to sanitation	Multiplier
watsafem	WATSAFE	Multiplier on percentage of people with access to safe water	Multiplier
watwastem	WATWASTE	Multiplier on percentage of people connected to wastewater collection system,	Multiplier
watwastetreatm	WATWASTETREAT	Multiplier on percentage of people connected to wastewater treatment	Multiplier
sanitationtrgtval/ sanitationtrgtyr	SANITATION	Target value and years after 2010 for target achievement for population percentage with improved access to improved sanitation, by category of	Relative target
watsafetrgtval/ watsafetrgtyr	WATSAFE	Target value and years after 2010 for target achievement for population percentage without access to improved sources of water	Relative target
sanitnoconsetar/ sanitimpconsetar/ sanithhconsetar/ sanitnoconseyrtar	SANITATION	Standard error targets and years after 2010 for target achievement for population percentage with varying access to sanitation	Relative target
Note: Using both *trgtval/trgtyr **and the** *setar/*seyrtar **parameters to affect the same outcome variable will block the impact of both, so users should be careful to only use one or the other of these types at a time, except in the case of fixed broadband, where the larger of the two effects will have an impact.**			

For the 5-tier model:

Parameter	Variable of Interest	Description	Type
watsafenewsw	N/A	Switch to activate 5-tier or 3-tier water model (0=3-tier model; 1=5-tier model)	Switch
sanithhmodel2sw	N/A	Switch to activate 5-tier or 3-tier sanitation model (0=3-tier model; 1=5-tier model)	Switch
sanithhm	SANITHH	Multiplier on percentage of people with access to sanitation by type	Multiplier
sanithhbasictrgtval sanithhbasictrgtyr	SANITHH	Target value and years from the base to reach at least basic sanitation services	Relative target
sanithhsafetrgtval sanithhsafetrgtyr	SANITHH	Target value and years from the base to reach safely managed sanitation services	Relative target

waterhhm	WATERHH	Multiplier on percentage of people with access to water by type	Multiplier
waterhhbasictrgtval waterhhbasictrgtyr	WATERHH	Target value and years from the base to reach at least basic water services	Relative target
waterhhsafetrgtval waterhhsafetrgtyr	WATERHH	Target value and years from the base to reach safely managed water services	Relative target

Water and sanitation only contains one parameter which directly affects physical infrastructure levels. This parameter is **landirareaequipm**, a parameter that affects the land area equipped for irrigation. All other parameters affect access to water, wastewater collection and treatment, and sanitation; the access rate then determines the expected/demanded level of the physical stock. There are no direct multipliers on physical stocks for these types of infrastructure. **Sanitationm**, **watsafem**, **watwastem**, and **watwastetreatm** are access parameters that affect access to sanitation, safe water, waste water collection, and waste water treatment, respectively.

Targeting parameters for water and sanitation are: **sanitationtrgtval/sanitationtrgtyr**, **watsafetrgtval/watsafetrgtyr**, **sanitnoconsetar/sanitimpconsetar/sanihhconsetar/sanitnoconseyrtar**, **watsafenoconsetar/watsafimpconsetart/watsafhhconsetar/watsafenoconseyrtar**, and **watwastetreatsetar/watwastetreatseyrtar**. The first two pairs provide absolute target values for sanitation and safe water access. The second two pairs define relative target values and years for reducing the number of people with no access to improved sanitation, safe water, or wastewater treatment.

ICT

Parameter	Variable of Interest	Description	Type
infratelem	INFRATELE	Multiplier on fixed-line telephone lines per 100 persons	Multiplier
ictbroadm	ICTBROAD	Multiplier on fixed-line broadband subscriptions per 100 persons	Multiplier
ictbroadmobilm	ICTBROADMOBIL	Multiplier on mobile broadband subscriptions per 100 persons	Multiplier
ictbroadtrgtval, ictbroadtrgtyr	ICTBROAD	Target value and years after 2010 for target achievement for number of subscriptions per 100 persons	Absolute target
ictbroadmobiltrgtval, ictbroadmobiltrgtyr	ICTBROADMOBIL	Target value and years after 2010 for target achievement for number of subscriptions per 100 persons; varies between 0 and 150	Absolute target
ictbroadmobilsetar, ictbroadmobilseyrtar	ICTBROADMOBIL	Standard error target and years after 2010 for target achievement for ICT mobile broadband access	Relative target
ictbroadsetar, ictbroadseyrtar	ICTBROAD	Standard error target and years after 2010 for target achievement for fixed broadband access	Relative target
ictmobilsetar, ictmobilseyrtar	ICTMOBIL	Standard error target and years after 2010 for target achievement for mobile phone access	Relative target
Note: Using both *trgtval/trgtyr **and the** *setar/*seyrtar **parameters to affect the same outcome variable will block the impact of both, so users should be careful to only use one or the other of these types at a time, except in the case of fixed broadband, where the larger of the two effects will have an impact.**			

Infratelem, **ictbroadm** and **ictbroadmobilm** are the only three multiplicative parameters that apply to ICT, and they serve to modify expected or demanded levels of access to telephones, fixed broadband, and mobile broadband respectively. IFs calculates broadband ICT slightly differently than other infrastructure types. Rather than being mutually exclusive, both absolute target values and relative targets (discussed in the paragraph below) apply to the calculation of ICTBROAD. Rather than calculating the value of the parameter adding the multiplier effect and then applying the relevant absolute and relative targets, which is what occurs in the rest of the infrastructure module, the calculation process differs markedly in regards to broadband. In this case, the value of ICTBROAD is calculated twice, once with and once without the application of the target access levels, and the larger of these two values is used by the model for calculations going forward. Then the multiplier **ictbroadm** is applied.

Ictbroadtrgtval/ictbroadtrgtyr and **ictbroadmobiltrgtval/ictbroadmobiltrgtvr** set absolute target values and years for fixed and mobile broadband access. **Ictbroadsetar/ictbroadseyrtar**, **ictbroadmobilsetar/ictbroadmobilseyrtar**, and **ictmobilsetar/ictmobilseyrtar** establish relative target access values for desired broadband access, mobile broadband, and mobile access respectively. Absolute and relative target parameters behave differently when used in combination with one another in regard to fixed broadband than in other infrastructure areas. Instead of canceling one another out, combining **ictbroadtrgtval** and **ictbroadsetar/ictbroadseyrtar**, causes the model to calculate both and then take the larger of the two values and use that.

Parameters to Affect Funding

Parameter	Variable of Interest	Description	Type
gdsm (infrastructure)	GDS	Gross domestic spending multiplier (infrastructure)	Multiplier
infrainvnewpubshrm	INFRAINVESTNEWPUB	Portion of new funding for infrastructure coming from public sources	Multiplier
Infrainvmaintpubshrm	INFRAINVESTMAINTPUB	Portion of maintenance funding coming from public sources	Ratio
hhsizem	GDS	Household size multiplier	Multiplier
infraroadpavedcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of paved roads	Multiplier
infraroadunpavedcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of unpaved roads	Multiplier
infraelecgencostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of electricity generation	Multiplier
infraelecaccruralcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of rural electricity access	Multiplier
infraeleaccurbancostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of urban electricity access	Multiplier
watsafecostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Cost of adding safe water connections to households	Multiplier
watsafeimpcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of improved safe water sources	Multiplier
sanitationcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of basic sanitation	Multiplier
sanitationimpcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of improved sanitation	Multiplier

watwastetreatcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of waste water treatment	Multiplier
landircostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of equipping land for irrigation	Multiplier
infratelecostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on cost of adding a fixed (telephone) line	Multiplier
ictmobilcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on cost of adding a new subscriber/mobile subscription	Multiplier
ictbroadcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on cost of adding a new broadband connection	Multiplier
ictbroadmobilcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on cost of adding a new mobile broadband connection	Multiplier

A number of major parameters for affecting the funding process in the infrastructure module exist. The first, more completely discussed in the [economic module](#) (in association with the social accounting matrix and government expenditures), is the government spending by destination multiplier **gdsm**. By manipulating the infrastructure component of **gdsm** users can change the proportion of government spending that goes towards infrastructure thus altering the amount of funding available to achieve the expected or demanded levels of core and other infrastructure; it can also be used to increase or decrease the spending on other infrastructure.

Public spending on infrastructure, both for new infrastructure and maintenance purposes, can be increased using the parameters **infrainvnewpubshrm** and **infrainvmaintpubshrm** respectively. Each of these parameters can be manipulated separately for different types of infrastructure, and changes to the public share will also affect private sector in a positive relationship (as public funding goes up so does private). Users can change the average household size using the parameter **hhsizem**, which has an indirect effect on budget by altering the total number of infrastructural connections required for a population[9]. Since budget availability affects attainment of infrastructure, as explained above, this parameter can ultimately change access rates.

Finally, users can also directly alter the unit cost of certain kinds of infrastructure, using one of a series of cost multipliers. The parameters **infraroadpavedcostm**, and **infraroadunpavedcostm** alter the unit cost of paved and unpaved roads respectively. **Infraelecgencostm** alters the cost of electricity generation, while **infraelecaccruralcostm** and **infraeleaccurbancostm** alter the cost of electricity access in rural and urban areas. The parameters **watsafecostm** and **sanitationcostm**, alter the cost of basic water and sanitation access while **watsafeimpcostm** and **sanitationimpcostm** change the cost of providing improved access to each. **Landircostm** changes the unit cost of equipping land for irrigation. **Infratelecostm**, **ictmobilcostm**, **ictbroadcostm**, and **ictbroadmobilcostm** all change the cost of different types of ICT.

Prepackaged Scenarios

Because of the complexity of the infrastructure module, and the sheer number of parameters it contains, users may wish to rely more heavily on prepackaged scenarios in order to find effective combinations of multipliers than they do in other IFs modules. One package of scenarios that was developed to model extensions of ICT broadband connectivity and resulting potential gains in efficiency of energy use was developed for the EU and includes modifications to a number of parameters. **Ictbroadm** is used to increase broadband penetration rates while **lke** (lifetime of capital in energy) increases the efficiency of energy capital investments, making energy production more efficient. This prepackaged scenario set can be accessed from the Scenario Development form of IFs, using

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[9] Household size parameters are applicable only for those types of infrastructure that are delivered at a household level, e.g., water, sanitation and electricity connections.

the Add Scenario Component menu option. The set can be found within the World Integrated Scenario Sets grouping where it is labeled ICT Scenarios for the EU. See Acknowledging Limits, Betting on Silver Bullets, Broadband Stupidity, and Networked Solutions (Moyer and Hughes, 2012).

Other Prepackaged Scenarios were developed for Chapter 6 of the Infrastructure volume of the *Patterns of Potential Human Progress* series (Rothman et al., 2013). This set of scenarios can be located in the PPHP InfrastructureChapter6 grouping of the World Integrated Scenario Sets. It contains a large number of scenarios using infrastructure targets. The scenario TarAllNNoBudgPriority, referred to as Universal Targets Pursuit in the volume, represents a future in which efforts are made to achieve universal access to water and sanitation, electricity, rural roads, and mobile broadband, as well as the elimination of solid fuel use, by 2030; no budget priority is given to infrastructure in this scenario. The scenario TarSENoBudgPriority has the same target date of 2030, but instead of universal access, countries only aim to achieve levels of access that exceed the expected value for their level of development by one standard deviation; again no budget priority is given to infrastructure. The other scenarios, TarAll2050NoBudgPriority, TarElecNoBudgPriority, TarICTNoBudgPriority, TarSE0NoBudgPriority, TarSENoP2050, TarTranNoBudgPriority, and TarWatNoBudgPriority, build on these two scenarios, adjusting the target level, the target date, or the categories of infrastructure with targets.

Agriculture Module

Variables of Interest

The IFs system models agriculture in terms of supply and demand. Consumption, from the demand side, links forward into food availability and nutrition. Both supply and demand dynamics in the agricultural module are closely linked to dynamics in the population and economic modules. For simplicity of representation, IFs models three primary foodstuffs: meat, crops and fish. Stocks (inventories) of food are driven by interaction between production and demand. Stocks affect

Variable Name	Description
AGDEM	Agricultural demand
FDEM	Food demand for consumption
FEDDEM	Feed demand for livestock
INDEM	Industrial demand for food
AGP	Agricultural production
YL	Yield per hectare of land
LD	Land area
AGM	Agriculture Imports
AQUACUL	Million metric tons of fish produced via aquaculture
AGX	Agriculture Exports
LOSS	Portion of food produced that never reaches markets
CLPC	Calories per capita
MALNCHP	Percent of children undernourished
MALNPOPP	Percent of population undernourished

prices and prices generate movement to supply and demand equilibration, a process that also involves trade.

The agriculture model represents demand for food (**AGDEM**) as a function of population size, population income, the share of income spent on food, and agricultural prices. A number of other variables also help to illustrate different aspects of the demand side of the equation. The first is food demand **FDEM**, which represents the amount of food demanded for human consumption. The second is **FEDDEM**, which represents the amount of food demanded for use as feed by livestock and the third is INDEM which represents the amount of food demanded for use in industrial processes. As a country develops, the balance between these types of demand change; in general, nations with more industry will have a higher level of industrial demand for food, and major meat producing nations will have a higher demand for crops to use as feed.

The supply of food produced within a country (**AGP**) consists of three dimensions crops, meat and fish. Crop production is a function of land (**LD**) and yields (**YL**). Meat production is the product of livestock herd size and the slaughter rate. The herd size changes over time in response to global and domestic meat stocks as well as changes in demand for meat and the amount of grazing land. Fish production has two components, wild catch and aquaculture. Wild catch is based on actual data whereas aquaculture is assumed to grow at a country specific growth rate.

A number of factors affect yield (**YL**) including: the level of technology, the amount of labor available for agriculture, the investment of capital into agriculture, and the propensity for yields to saturate at some point even in the face of progressively increased input levels. Investment in agriculture is driven by product prices relative to the additional capital investment required and therefore profit levels. Given the common cycles in agriculture and long lead times in response to investment, however, farmers cannot always make decisions based on current conditions. Investment is also directly responsive to global inventory or stock levels and has an inertial component.

IFs also represents losses to the agricultural production system, and they can have a powerful impact on the availability of food in a country. Not all of the food produced within a country makes it to a market, because of poor infrastructure, such as a lack of refrigeration or other inefficiencies in the production system. In IFs this process is represented via the **LOSS** variable. For higher income countries, a larger portion of the loss is actually on the demand or consumption side. Because agricultural products are globally traded commodities, imports and

exports of food, discussed in the [economic module](#) as well, play an important role in moderating the availability of food within a country. In IFs these are represented by the variables **AGX**, agricultural exports, and **AGM**, agricultural imports.

The dynamics of the above processes ultimately affect the ability of people in a country to avoid malnutrition in the form of either obesity or starvation. In many developing nations, meeting daily caloric needs is a struggle and large portions of the population in these countries may be undernourished, leaving them vulnerable to death by preventable diseases. This is especially true of children, for whom the consequences of both short and long term under nutrition are especially severe. To help users keep track of this essential developmental indicator, IFs includes a number of variables that represent the nutritional challenges faced within a country. First, calories per capita (**CLPC**) provides a rough measure of the total number of calories available to individuals. It provides a rough guide to the kinds of nutritional challenges a nation may face. Populations getting less than approximately 2100 calories a day may experience higher levels of malnutrition, while those that are getting significantly above 3000 calories a day may experience increasing levels of overweight and obesity. However, more important than a crude measure of calorie availability is the impact that chronic undernourishment poses from a development standpoint. To illustrate this burden, IFs includes variables that provide the percentage of the population that is undernourished (**MALNPOPP**). Data tend to be better for child undernutrition and we typically have more confidence in and pay more attention to the variable that indicates the percentage of a country's children (under five) who are undernourished (**MALNCHP**).

Parameters to Affect Demand

Parameter	Variable of Interest	Description	Type
clpcm	AGDEM	Multiplier on all per capita caloric demand	Multiplier
elascd	AGDEM	Elasticity of crop demand to changes in food price	Elasticity
elasmd	AGDEM	Elasticity of meat demand to changes in food price	Elasticity
elasfd	AGDEM	Elasticity of fish demand to changes in food price	Elasticity
indemm	INDEM	Industrial demand for crops	Multiplier
clpccvm	CLPCCV, MALNPOPP	Multiplier on coefficient of variation for calories per capita	Multiplier

A brute force multiplier on agricultural demand (**clpcm**) allows direct manipulation of demand and can be used to represent a wide range of scenarios relative to the Base Case, including changing tastes among consumers, changing responses to prices, and changes in incomes or the movement of individuals into the middle class. Changes in consumer desires for certain foods could also be modeled using the parameter **clpcm** which also adjusts the portion of calories obtained from meat. It is a multiplicative parameter, so a 0.2 increase in the value of the parameter from its base value of 1.0 would generate a 20% increase in the value of the variable relative to the base case. However, this is a relatively difficult parameter for which to identify reasonable values for such changes. Similarly, changes to **elascd** (elasticity of crop demand to changes in price), **elasmd** (elasticity of meat demand to changes in price) and **elasfd** (elasticity of fish demand to changes in price) should be made with caution because they involve changing the responsiveness of demand to changes in price. Such parametric interventions might be appropriate in cases where you want to model the impact of a mass movement to change diet patterns, such as in response to a national campaign for healthy eating or decreased meat consumption due to preference changes. In all three cases the relevant outcome variable is **AGDEM**. Also, the parameter **indemm** can be used to manipulate levels of industrial demand for crops.

Parameters to Affect Supply (Production)

Parameter	Variable of Interest	Description	Type
tgrld	AGP	Target growth rate in cultivated land	Initial Condition
ylm	YL	Crop yield (agricultural production)	Multiplier
ylmax	YL	Maximum crop yield	Exogenous specification
envylchgadd	ENVYLCHG	Agricultural yield change	Additive factor
slr	AGP	Livestock slaughter rate	Exogenous specification
livhdpro	AGP	Livestock herd productivity gain with grain feeding	Exogenous specification
aquaculm	AGP	Fish production through aquaculture, multiplier	Multiplier
aquaculgr	AQUACUL	Growth in the use of aquaculture	Growth Rate
aquaculconv	AQUACUL	The number years in which aquaculture growth rate converges to 0	Convergence rate
fishcatchm	AGP	Fish production through wild catch	Multiplier
aglosstransm	AGLOSSTRANS	Agricultural wastage	Multiplier
aglossprodm	AGLOSPROD	Agricultural production loss	Multiplier
aglossconsm	AGLOSSCONS	Food consumption loss	Multiplier
aginvm	YL, IDS (agriculture)	Investment in agriculture	Multiplier
elagind	AGP	Elasticity of industrial use of crops with energy price	Elasticity
elinag1	IDS (agriculture)	Elasticity of investment in agriculture to profit levels	Elasticity
elinag2	IDS (agriculture)	Elasticity of investment in agriculture to changes in profit level	Elasticity
ldcropm	LD(crop land)	Share of crop land in total land	Multiplier

There are two primary channels to think about changing the supply of agricultural production. The first is via increases in the amount of resources devoted to agricultural production such as by increasing the amount of land under cultivation. This can be done via the **tgrld** parameter. The earth's arable land is relatively finite, however, and land under cultivation has not been a major driver of increased production for decades in most countries.

A more appropriate channel to think about is technological change that increases the efficiency of food production systems thereby increasing yield. The yield multiplier (**ylm**), which affects the yield of land being used for crop production, could be used, for example, to model the effect of a second green revolution. This parameter does not carry an intrinsic cost to use, making it both a powerful way of affecting the agricultural model, but also making it

essential to justify the reason for any yield change. For example, this multiplier could be effective in representing the impact of improvements to climate or technology that increase the output of a particular unit of land in the absence of increased labor or investment. Users can also alter the maximum yield that can be harvested from a plot of land using **ylmax**, an exogenous parameter which sets a maximum level for yield. Changes to this parameter can model extreme changes to land yield, such as a second green revolution. Moreover, the parameter **ldcropm** can be used to change the share of crop land in the total land.

Another parameter that can be used to affect yield is **envylchgadd**, also discussed in the environmental module. It can be used to model the effect global warming is having on agricultural yields. Modifying this parameter allows users to test different assumptions about the effect that increased CO_2 and increased temperatures will have on crop yield.

Changes in the patterns of production of meat and fish can be modeled in the IFs system through a number of parameters. Meat production can be affected by changing the rate at which livestock are slaughtered via **slr**. This parameter could be altered to model the transition from subsistence to factory farming, and the increasing use of modern slaughterhouses in developing countries. The parameter **livhdpro** is also useful for modeling the impact of increased meat production from livestock as a result of the transition to grain feeding, which allows producers to extract more meat from each animal they own.

Similarly the parameters **aquaculm** and **aquaculgr** can be altered to model the impact of increasing reliance on aquaculture for fish production because of technological improvements to this method of food production. The variable of interest will be FISH. The parameter **aquaculm** works like other multiplicative parameters, while the parameter **aquaculgr** alters the rate at which the use of aquaculture increases. The first parameter targets the actual amount of aquaculture a country uses, and is easiest to manipulate for the average user. The second, **aquaculgr**, is set within the model and alters the rate at which countries begin to develop aquaculture resources. Finally the parameter **aquaculconv** can be used to determine the number years in which aquaculture growth rate converges to 0.

Other parameters that affect the level of fish production include **fishcatchm** and **aquaculm.** The first, modifies the amount of fish catch while the second**,** changes the rate of catch from aquaculture.

Changing the loss rate of agricultural output to waste (rotting in fields, lost/spoiled during transportation, or not used in the home) via the **aglosstransm** parameter is a powerful way to model the impact of changing agricultural distribution loss of food. It is a multiplicative parameter. Moreover production losses and consumption losses can be manipulated through the parameters, **aglossprodm** and **aglossconsm** which allow the user to specify the rates of production losses and consumption losses respectively.

Technological improvement is not the only pathway through which yield (YL) may be affected within IFs. Financial pathways can change the amount of capital being invested in agriculture, resulting in higher yields. For example, parameter **aginvm**, directly changes the investment in agriculture. This parameter can be used to model the effects of investment in improved agricultural technologies like genetically modified crops or new methods of aquaculture. Because of the financial accounting systems within IFs, changes in agricultural investment will affect investment in other sectors. **Elagind** is a parameter that may be useful those who wish to adjust the percentage of crop production that is diverted for industrial uses such as ethanol, or beer.

Parameters to Affect Nutrition

Parameter	Variable of Interest	Description	Type
malnelimstartyr	MALNPOP	Undernourishment elimination start year	Standard error target

malnelimtargetyr	MALNPOP	Undernourishment elimination target year	Standard error target
malelimprecisesw	MALNPOP	Undernourishment elimination	Switch

Finally, model users may wish to use parameters to explore the health and economic impacts of different levels of nutritional deficiencies. In the health model, nutritional deficiency manifests itself in terms of mortality and morbidity related to communicable diseases. It can have especially large effects on children, who if undernourished for a significant period of their childhood, suffer developmental and cognitive delays that can impact their future productivity. The most important of these parameters are **malnelimstartyr** and **malnelimtargetyr,** which are standard error target parameters that affects the number of undernourished people in a country as a percent of the population. These parameters could also be used to represent the impact of school based nutrition programs or other targeted feeding programs. The parameter **malelimprecisesw** is a switch that when activated calculates the required number of calories to eliminate hunger for the most undernourished part of the population.

Prepackaged Scenarios

One prepackaged scenario that makes significant improvements to agricultural yield in the developing world was developed as a policy brief, and models the impact of a green revolution in Africa. The scenario combines multipliers and other parameters, including **ylm, ylmax, aginvm,** and **tgrld**. It was designed to model the impact of a green revolution type of event occurring in the developing world and involving improved yield of crops through improvements in cultivation techniques and new technologies. Users will find it saved under the African Policy Briefs section of the World Integrated Scenario Sets, under the heading Green Revolution, which is also the title of the scenario. It increases agricultural yields by 76 percent over a 32-year period (increasing the parameter **ylm** to 1.76). It also increases the maximum yield in all African countries, as well as modeling 20 percent growth in agricultural investment and an initial target for growth in cultivated land of 8 percent.

Another prepackaged scenario that makes significant changes to agriculture is the Politics of Belly scenario developed for the African Futures 2050 project. This scenario is located in the Afp 2050 folder in the World Integrated Scenario Sets heading. This posits a much less positive outlook for African agriculture, simulating a 20 percent decline in yields that could represent the negative impact of climate change, much more than offsetting the mitigating effect that plant responsiveness to C02 increases might have on yields.

Energy Module

Variables of Interest

Rapid development of unconventional oil and gas production—particularly from shale sources—and high rates of growth in energy from renewable sources make the future of energy highly uncertain. Several research organizations have forecasting projects that provide long-term analysis. In the United States, the Department of Energy's Energy information Agency produces a yearly report titled, *International Energy Outlook;* the International Energy Agency produces similar forecasts for the world as a whole, as well as for many individual countries, in its annual *World Energy Outlook.* The IFs energy module contributes to this existing body of research on international energy futures. A selection of variables and parameters allows users to explore alternative patterns of energy demand, production, resource discovery and technological developments.

Variable Name	Description
ENDEM	Energy demand
WEP	World energy prices
WEPBYEAR	Translates global energy prices into dollars per barrel of oil equivalent
ENPRI	Energy prices
ENST	Energy stock
ENRGDP	Ratio of energy demand to GDP
ENP	Energy production
WENP	Global energy production
KS	Capital stock
IDS	Investment in energy
QE	Capital output ratio
RESER	Accessible energy reserves
RESOR	Ultimate conventional energy resources
RESORUNCON	Ultimate unconventional energy resources
ENM	Energy imports
ENX	Energy exports
ENSHO	Energy shortage
VADD	Value added, energy

The structure of the IFs energy model is similar to that of the agriculture module, discussed in the preceding section. Both systems are driven by demand and supply dynamics within an equilibrium-seeking system that involves prices, trade, and investment. In both cases, the model translates forecasts of the physical system into value terms for the economic module and interaction with other sectors. The size of the economy and population shape demand, which IFs represents in the aggregate (not within sub-categories such as transportation, residential/commercial and industrial). The supply side differentiates production dynamics for oil, gas, coal, hydroelectric, nuclear, and other renewable energy and separately represents conventional and unconventional energy resources, such as shale deposits.

Beginning our elaboration with the demand side first, IFs derives each country's energy demand from the overall size of the economy, the level of development as measured by GDP per capita, and world energy prices. The variable **ENDEM,** displayed as a default in billion barrels of oil equivalent (BBOE), captures demand from all sectors, and for all types of energy. The energy intensity of an economy—the usage of energy per unit of GDP (**ENRGDP**)—is a very important measure, influenced by the development level, the advance of technology, and energy prices. Reductions in that, or improvements of efficiency over time, have been occurring in most countries. Users may explore several different formulations of energy price, which is a key factor used to derive demand and affect the energy intensity. **WEP** is a single composite measure of the global price of energy, expressed as an index

with a base of 100 in the first model year (**WEPBYEAR** translates global energy prices into dollars per barrel of oil equivalent). Like **WEP**, **ENPRI** displays country-level energy price as an index, base 100. Each country's price is a function of global capital costs of energy production and a regional markup factor that reflects the level of country-specific energy stocks (**ENST**).

Key indicators for the other side of the energy system, the supply side, include production, capital/output ratio and available natural resources. Production is measured in the variable **ENP**; production can be displayed as a total, or disaggregated through the energy type dimension to produce individual displays of oil, natural gas, coal, hydroelectric power, nuclear, and other renewables. **WENP** is energy production for the world as a whole, disaggregated by production type. For each country, energy production is partially determined by relationships around capital. The portion of the initial capital stock dedicated to the energy sector, **KS**, limits the scale of possible production. And the capital-output ratio, **QE**, translates capital stock (**KS**) into production level. Capital stock itself is augmented over time by investment, **IDS**, dependent on the profitability of investment in energy.

The concept of capital-output ratio (**QE**) warrants clarification because it is important to the energy module's equilibrating dynamics. When production requires relatively little invested capital to produce a unit of output, the capital-output ratio is low. Conversely, a high ratio would mean a large amount of capital is required to produce a unit of output. All things equal, the lower the capital-output ratio, the greater the opportunity for profits. Thus, in the model, a low **QE** will generally trigger an increase in production.

Available natural resources are the final factor constraining supply. Levels of proven reserves, **RESER**, drive the price structure component of production—by affecting **QE**. Proven reserves are in turn bounded by the availability of ultimately recoverable resources, displayed in the variable **RESOR** for conventional resources, and the variable **RESORUNCON** for unconventional resources, both of which must be discovered (**RD**) to become reserves. As we shall see in the discussion of parameters, **QE** is affected not just by resource constraints, but also by the advance of technology.

A set of trade variables measures countries' external reliance on energy. While high levels of energy exports can enrich public finances through taxation, an overreliance on either energy imports or exports increases vulnerability to external price shocks. Energy imports and exports are measured in billion barrels of oil equivalent by **ENM** and **ENX** and represent aggregate trade in energy without distinguishing energy types. A more direct indication of vulnerability to shock is located in Flexible Display, under the heading Energy Imports as a Percent of Total Demand.

Disruptive price swings are inherent to any commodity market. In energy markets they can result from either political disruption in energy producers such as Iraq or from collusion among producers—evidenced by the cartel behavior of The Organization of Petroleum Exporting Countries (OPEC). As economists point out, prices can theoretically always rise or fall to balance demand and supply—to clear the market. But as history has shown, severe energy shocks, sometimes in environments where leaderships do not allow prices to fully adjust, can result in actual physical shortages (**ENSHO**). In normal years the level of energy stocks in a country is visible through the variable **ENST**.

A final set of indicators, measured not in physical but in monetary value terms, represents the overlap between the energy and economic modules in IFs. The variable **VADD** displays the total value added that is contributed to a country's GDP by various sectors, including energy; this gives a quick look at how much a country relies on energy production as a source of wealth. Investment (**IDS**) and capital stock (**KS**) present additional measures of the size of the energy sector in absolute terms and relative to other sectors.

Parameters to Affect Demand

Parameter	Variable of Interest	Description	Type
endemm	ENDEM	Energy demand	Multiplier
elasde	ENP, WEP	Price elasticity of energy demand	Elasticity
carbtax	ENP	Carbon tax	Exogenous specification
enrgdpgr	ENP, QE	Growth in energy efficiency/ Energy demand to GDP ratio	Rate of change

The demand side of the energy system features several leverage points that can be used to create alternative scenarios. The multiplier **endemm** directly manipulates aggregate energy demand in a country or region relative to its underlying calculation from economic size and other driving variables. A second key demand-side parameter, **enrgdpgr**, allows the user to change the default rate of change in energy intensity (the inverse of energy efficiency). Turning from the more brute-force parametric intervention approaches to a more policy specific one, country-level energy prices and therefore energy demand can also be manipulated directly through the additive parameter **carbtax**. As the name implies, this parameter simulates the effects of a tax on carbon emissions—even employed at a reasonable level, a carbon tax can have substantial impacts on energy demand.

In the energy analysis community there is always some uncertainty and debate concerning the strength of the relationship between energy price and demand. The parameter **elasde** allows users to change the long-term price elasticity of demand. This elasticity is negative in the model, corresponding to traditional formulations of supply and demand—as prices rise demand for energy falls. Users building scenarios may wish to experiment with different values of **elasde**, while bearing in mind the possibility that long-term and short-term elasticities may differ.

These demand-side leverage points offer a rich area for experimentation. Work by groups such as the International Energy Agency (IEA) and the International Panel on Climate Change (IPCC), have simulated several alternative future forecasts for energy efficiency development.

Parameters to Affect Supply

Parameter	Variable of Interest	Description	Type
enpm	ENP	Energy production multiplier	Multiplier
eprodr	ENP	Energy production growth rate	Growth rate
resorm	WRESOR	Ultimately recoverable conventional resource multiplier	Multiplier
resorunconm	WRESOR	Ultimately recoverable unconventional resource multiplier	Multiplier
rdm	RESER	Energy Reserve Discovery multiplier	Multiplier
etechadv	QE	Rate of technical advance in energy	Exogenous specification
etechadvuncon	QE	Rate of technical advance in unconventional energy	Exogenous specification
qem	QE	Capital output multiplier	Multiplier
eninvm	ENP	Energy investment	Multiplier
enprix	ENPRI	Regional energy price	Exogenous specification
enml, enxl	ENM, ENX	Limits on energy imports and exports	Exogenous specification

Turning to the supply side of the IFs energy module, two parameters in the model directly alter the relative production of oil, gas, coal, hydroelectric, nuclear, and other renewable energy. **Enpm**, a multiplier, scales up or down existing production of a specified energy type; **eprodr**, a growth rate parameter, forces a specified yearly percentage increase in production on the desired energy type. Both types of direct production modification can be used to trace the effects that a shift in energy production profile may have on life in a country, region, or the entire global community. For some observers, renewables represent the most important source of uncertainty surrounding the character global energy production. The IFs Base Case forecast assumes that renewable energy will grow rapidly in importance in the decades to come – see **WENP** across all energy types for a clear depiction. What if the model's baseline assumptions are too optimistic, or too pessimistic? Scenarios created with **enpm** and **eprodr** can explore variations on the Base Case renewable energy story.

Moving below the direct interventions on production to parameters that affect the drivers of that production, both conventional and unconventional deposits of oil, gas and coal resources offer possible points of leverage for supply-side energy scenarios. As mentioned above, IFs divides raw materials used in energy production into resources and reserves. Scenario interventions are most effective when they include simultaneous changes to the reserves that are very closely tied to production, and to the more distil element of total resources (resources only become reserves when they are discovered and deemed to be economically exploitable with current technology and prices). An increase to the **resorm** or **resorunconm** parameters will expand the amount of materials that can potentially transition to reserves and become economically viable. As a second step, users can speed up this transition by manipulating **rdm**, a parameter that represents the rate of geologic discovery (or improved economic exploitability) in a country. An increase in the stock of fossil fuel reserves creates the possibility that they will be produced and that they will have forward impacts on energy price (**ENPRI**) and **GDP** of energy producing countries.

A key source of uncertainty around the future of energy supply concerns production costs. Technological progress could dramatically increase the amount of energy output possible at current levels of investment. The parameters **etechadv** and **etechadvuncon** directly control the rate of technological advance and cost reduction by energy type, whether based on fossil fuels or renewable energy. For fossil-based energy in particular, several other parameters

enable users to explore the consequences of various energy production cost structures. **Qem**, a capital-output multiplier, directly scales up—or down—the capital cost per output unit of each energy type at the country level.

Government policies could additionally affect the future of energy production. Actions such as tax increases or direct subsidies can be simulated using **eninvm**, an investment multiplier. The parameter either increases or decreases overall investment in energy—the model still controls which energy-type is affected, based on price signals. Remember that the equilibrating mechanisms of the model will respond to any change in investment patterns. For example, an increase in investment flowing to oil, would increase production, eventually reducing oil prices, and leading to a subsequent decrease in investment. Remember also that the accounting mechanisms of the model will assure that any additional investment in energy will come from somewhere, such as investment in other sectors, other government expenditures, or household consumption.

Government decisions can also affect energy prices quickly, through intentional price shocks similar to those initiated by OPEC in the 1970s. The **enprix** parameter can simulate a concerted effort on the part of energy exporters to fix prices; **enprix** exogenously sets the type-specific energy price—**ENPRI**— for a region. As in real life, any price fixing scenario will have wide-ranging, and potentially perverse economic consequences. Two additional parameters exist that can simulate short-term supply disruptions via trade restrictions: **enml** exogenously imposes a limit to energy imports and **enxl** imposes a limit to energy exports.

Prepackaged Scenarios

Currently, none of the prepackaged scenario files demonstrate the use of parameters linked to the energy module.

Environment Module

Variables of Interest

As the global population has grown, and more and more countries have industrialized, sustainable development has come to occupy a permanent place on national, regional and global agendas. Growing concern for the environment was brought to the fore at the 1992 UN Conference on the Environment in Rio de Janiero. More than 2 decades have passed since the Rio conference, and the global community's dedication to environmental concerns (if not always to action) has remained strong. In 2012 a follow up conference was held in Rio—the United Nation's Conference on Sustainable Development, or Rio + 20—at which leaders discussed strategies to end poverty, address environmental destruction and build a bridge to the

Variable Name	Description
CO2PPM	CO2 parts per million
CO2PER	Percentage increase in atmospheric CO2
CARANN	Annual carbon emissions from fossil fuels
CARFOROTH	Annual net carbon release from forests
WTEMP	Average annual world temperature
ENVTPCHG	Annual average temperature change from 1990
ENVPRCHG	Annual average precipitation change from 1990
WFORST	World forest area
LD	Land area by type
WATUSE	Annual water usage
WATUSEPC	Annual water usage per capita
ENVPM2PT5	PM2.5 levels in residential areas
ENSOLFUEL	Solid fuel use
CLIMECONIMP	Climate change to economy impact

future. Other forward-looking environmental initiatives include the United Nations Environment Program's (UNEP) Global Environmental Outlook Series. Since the first entry in the series, published in 1997, the UNEP has followed up with four additional reports (the International Futures model contributed to the most recent report). Despite the creation of dozens of internationally agreed upon goals, 2012's *Global Environmental Outlook 5* warned that the world remains on an unsustainable path. Around the world, forestland is decreasing, centuries-old glaciers are retreating, aquifers are being depleted and the amount of atmospheric carbon dioxide is on the rise. Not all environmental trends are negative, however. Developed countries have made progress on urban air pollution. Developing countries have experienced improved drinking water quality and safe sanitation access. And globally, the volume of CFCs damaging the ozone layer has dropped dramatically over the course of recent decades.

Environmental issues have potential or actual connections to all of the modules in IFs. For instance, processes associated with energy, agriculture, infrastructure, and the broader economy directly impact the earth's forests, water supply, and atmosphere, as does governance more indirectly. The environmental module elaborates a subset of these potential connections in four specific areas: the global carbon cycle, land use (notably forest area), water use (agricultural), and air quality (urban and indoor).

The numerous ways in which human actions influence the environment are evident throughout the carbon cycle. Carbon is continuously moving within and across the boundaries of the Earth's atmosphere, hydrosphere and biosphere. In systems dynamics terminology, the elements in the cycle are known as stocks and flows. Put simply, stocks are long-term repositories of carbon such as the world's fossil fuels, biomass and oceans, and flows are movements from one stock to another. This stock-flow dichotomy serves as a useful heuristic for users who are interested in creating scenarios in the IFs environment model more generally, but especially with respect to carbon. Interventions can target carbon stocks through processes that affect flows, such as energy production and reforestation. Key carbon stock indicators are **CO2PPM**, the level of atmospheric carbon dioxide measured in parts per million, and **CO2PER**, atmospheric carbon dioxide, measured as a percent relative to pre-industrial levels. On

the flow side, key indicators available in the model include **CARANN**, the annual flow of carbon emissions from fossil fuel use, and **CARFOROTH**, global net carbon released annually from forests and other sources (discussed below). As we shall see, the model also allows parametric control of the flow of carbon from the atmospheric stock to that dissolved in the oceans, another stock.

The atmospheric carbon stocks have important forward linkages. One of the most important, temperature change, can be tracked via **WTEMP**, the global average annual temperature in degrees centigrade. A derivative temperature variable but at the country level, **ENVTPCHG**, captures the average annual temperature change from the year 1990, and **ENVPRCHG** similarly tracks the change in precipitation. These have further forward linkages to agriculture.

Several variables in the model measure the configuration of the world's land area. Two variables capture trends in forest coverage: **WFORST** is an aggregate measure of the world's land area covered by forest, reported in millions of hectares; and the land variable **LD** is disaggregated by land type, enabling country- or region-level displays of the following categories: crop, grazing, forest, urban and other. (See the agricultural module for a complete discussion of land use variables and parameters). Land use links back to the carbon representation because trees and other plants making up the world's forests absorb carbon dioxide through photosynthesis and their carbon content is still another important global stock. As indicated above, change in forest area, such as clearing of land for agricultural use, generates one of the carbon flow terms of the model.

The environment submodule includes water indicators. The annual use of freshwater resources is reported in cubic centimeters via **WATUSE,** tied in IFs to the major source of water use, agricultural production. Users can additionally choose to explore water use per capita, expressed in thousands of cubic meters, via the variable **WATUSEPC**. Currently, the model's treatment of water does not feature the stock and flow elements seen in the carbon cycle. Although **WATUSE** is a flow of water used each year, no corresponding variable captures the total stock of water—say in nonrenewable (or at least very slowly recharging) fossil water aquifers. This is a shortcoming that we hope to address in the near future. However, a parameter, **watres** (see the discussion below), does provide an estimate of the level of annually renewable water resources in countries and regions. The ratio of use to renewable resources serves as a measure of relative water stress. With respect to forward linkages, water stress is one of the drivers of state fragility (see the government module).

A set of environmental indicators pertains to air pollution. The amount of solid matter suspended in the Earth's atmosphere serves as a measure of relative air quality; high levels of atmospheric particulate matter (PM) can have adverse effects on human health. Depending on the data source, PM concentration readings may include particles that are either 10 or 2.5 micrometers in diameter. In the model, the variable **ENVPM2PT5** captures levels of fine particulate matter, PM2.5, found in residential areas (although our current data source is actually for 10 micrometer particulates). The prevalence of solid fuel use is a second indicator of air pollution. The variable **ENSOLFUEL** captures the percent of a population relying on solid fuel as the primary source of domestic energy. Burning solid fuel, such as wood, peat, coal, dung, and certain grains, produces a toxic environment indoors (see the infrastructure module).

Finally, one indicator pertains to the impact of climate change on the economy. **CLIMECONIMP** feeds forward the impact of climate change to the GDP. This is done through a quadratic formulation that was originally developed by Nordhaus.

Alternative scenarios, built in any IFs module, are likely to have bearing on environmental indicators. Users exploring the consequences of scenario interventions in economics, energy or agriculture are likely to see the greatest environmental effects. Interventions in other modules will still affect the environment, though through weaker, more distal, drivers. The environmental sub-module, however, allows users to directly explore the effects of environmental change. Environmental parameters can be categorized as those that affect carbon stocks and flows, land use, water resources, and air quality.

Parameters Affecting Carbon

Parameter	Variable of Interest	Description	Type
enpm	ENP	Energy production by type	Multiplier
endemm	ENDEM, WEP	Energy demand multiplier	Multiplier
carbtax	ENP, CARANN	Carbon tax	Exogenous Specification
qem	ENP	Capital-output ratio multiplier	Multiplier
resorm	RESOR	Resource multiplier	Multiplier
enrgdpgr	ENP	Energy efficiency	Growth rate
carfuel1	CARANN	Carbon generated by oil	Coefficient
carfuel2	CARANN	Carbon generated by natural gas	Coefficient
carfuel3	CARANN	Carbon generated by coal	Coefficient
envclimsens	CO2PPM, WTEMP	Time sensitivity of global temperature to carbon dioxide	Limit
carabr	CO2PPM, WTEMP	Carbon absorbed by oceans and non-forest land sources	Coefficient
carabrchng	CO2PPM, WTEMP	annual change in this absorption rate of carbon by oceans and non-forest land sources	Coefficient
envco2fert	AGP	Crop sensitivity to environmental change	Elasticity
envylchgadd	ENVYLCHG	Agricultural yield change	Additive factor
envylchgm	ENVYLCHG	Multiplier on annual change in agricultural yield	Multiplier

There is no way to directly target atmospheric carbon stocks in the model. Instead, points of intervention involve flows, the most important of which is the burning of fossil fuels and therefore the rate of flow of carbon from its stock in those fuels to the stock in the atmosphere With respect to fossil fuel use, there are leverage points on both the production and consumption side—see the energy model discussion. **Enpm**, the energy production multiplier, will alter the flow of carbon into the atmosphere and can serve as a powerful leverage point in energy-driven environmental scenarios. Users can alter the mix of energy types produced within a country, thereby reducing or increasing the use of fossil fuels, and trace the environmental effects.

On the demand side, a reduction in **endemm**, the energy demand multiplier, can likewise simulate conservation/efficiency enhancement programs that alter the flow of carbon into the atmosphere. It is important to note that reductions in energy use triggered by **endemm** are free; that is to say, they are not accompanied in the model by economic costs. In reality, conservation or efficiency efforts occasionally do reduce energy use without a large cost—as evidenced by voluntary behavioral shifts on the part of citizens, or regulations enforced by the government. However, because it may be unrealistic to assume costless energy demand changes, users may wish to include financial considerations in their scenarios. The parameter **carbtax** simulates a reduction in demand triggered by tax; users would pay an additional fee on fossil fuels proportional to carbon content. This would encourage conservation or a transition to less expensive forms of energy. Users experimenting with carbon taxes should observe the effects on the energy production system **(ENP)**, the level of annual carbon emissions **(CARANN)**, world temperature **(WTEMP)** and the level of economic output **(GDP)**.

Users can also simulate government interventions designed to encourage research and development focused on renewable energy or energy efficiency. Each energy type's cost profile is linked to a capital-output ratio multiplier, **qem**. Users can simulate a decrease in the cost of renewables by reducing the multiplier's initial value from 1.0 to 0.8—this would reduce all production costs by 20 percent (on top of whatever cost changes the model endogenously computes). Energy prices can also be indirectly controlled by changes to natural resources needed to produce fossil fuels. As oil and gas resources are exploited, the remainder becomes more expensive to extract. Users can use **resorm** to enforce alternative assumptions about the scale of ultimate resources available for discovery, and eventually, production. Mechanisms involving resources, reserves, and energy price operate over a long time horizon. Any scenario using **resorm** should be run out to at least the year 2050 in order to display significant forward linkages.

Changes in the efficiency of energy use from oil and gas sources would have bearing on carbon emissions as well. Changes in energy efficiency are controlled by the growth rate parameter **enrgdpgr** in addition or instead of the use of **endemm.** Changes to this parameter simulate the impact of successful research and development programs in the public or private sphere. Three parameters offer an additional way to simulate improvements to energy efficiency: **carfuel1, carfuel2** and **carfuel3** set, respectively, the amount of carbon emitted by burning oil, natural gas and coal. Normally these should be considered physical constants and not changed, but the model does not contain a representation of carbon sequestration and **carfuel3** could be used to represent its impact, although not its cost. For a complete discussion on parameters pertaining to energy production see the [energy section](#).

Returning to the issue of stock-to-stock flows of carbon, so far we have focused only on the movement of carbon from fossil fuels to the atmosphere. Not all carbon emitted into the atmosphere remains there, and the model contains parameters to control the absorption of atmospheric carbon by the oceans. Two parameters control this process in the model. The first is **carabr**, an exogenous specification of the billion tons of carbon that annually moves to or is absorbed by the oceans. The second is **carabrchng**, which sets the annual change in the absorption rate (a measure of flow). At this point the parameter is not functional, and the user should be aware that change in it will have no effect. The final stock-to-stock flow represented in the model is between the atmosphere and forests (to be discussed below). Because the model does not explicitly represent the flow between the atmosphere and other non-forest vegetation (or organic matter in the soil), users with interest in this area could turn to the parameter **carabr** to implicitly capture, not just absorption into oceans, but into other matter as well.

Turning to forward linkages, future trends in the carbon system will affect the world's agricultural sector. The stock of atmospheric carbon dioxide (**CO2PPM**) and the related level of global temperature (**WTEMP**) are the variables that transmit the carbon system's effects. The model represents two major paths of impact, one related to each variable. The first path is the so-called carbon-fertilization effect. Because plants need carbon, an increase in **CO2PPM** can actually increase agricultural yields, and the parameter that controls that is **envco2fert**, crop sensitivity to atmospheric carbon dioxide. A value of zero would turn off this linkage.

The second path is from global temperature (**WTEMP**) to country-specific temperature and precipitation changes (**ENVTPCHG** and **ENVPRCHG)** and then to agricultural yield. The translation in the model of changes in global temperature to changes in country-specific temperature and precipitation uses information from climate-specific models and is not subject to parametric control by users (in modeling terminology, they are "hard-coded" within the model). The user can, however, affect the further impact of country-specific values to yield. While the model's formulation for that impact (**ENVYLCHNG**) on yield is quite complex, two parameters exist for influencing it, the multiplicative parameter **envylchgadd** and the additive parameter **envylchgm.** Their effects are sequential, so it is best that the user rely on one or the other, not both.

One additional parameter is important in this consideration of forward linkages, namely that which controls the translation of atmospheric carbon levels (**CO2PPM)** into global temperature (**WTEMP**). That parameter is **envclimsens**, the time sensitivity of global temperature to carbon dioxide. The very large-scale global circulation models of climate change struggle to make the connection between these two variables and IFs uses this simple

parametric linkage to summarize some of what we have learned from them. But the relationship is uncertain, so a scenario that would raise or lower the parameter and the impact on global temperature might be of interest. Moreover, the impact of carbon on temperature is likely to be one that involves lags (increasing temperature slowly even at a given fixed level of raised carbon dioxide), so one could consider a dynamic value of the parameter over time in order to capture that.

Land Use

Parameter	Variable of Interest	Description	Type
forestm	WFORST	World forest multiplier	Multiplier
carforst	CO2PPM	Level of carbon sequestered by forests	Coefficient

The importance of land extends beyond its role in carbon cycle. We are interested in forest area, for instance, due to its involvement in species preservation, in water cycle control, and for its own intrinsic value. A direct multiplier, **forestm**, imposes an increase or a decrease on a country's forest area. Any change in land area is constrained by a country's geographic size because an increase in forest area requires a corresponding decrease in the land available for other types of use, such as crop production. As another way to affect land use, the parameter **tgrld** sets an initial target for annual growth in cropland. This second parameter achieves a change in land devoted to crops primarily as a trade off with forest area. For a complete discussion of parameters concerning patterns of land use, see the agricultural section. Changes in land use will, of course, have secondary consequences visible in **GDP**, **AGP**, **AGX**, and **AGM**, among other variables

Returning to the role of forests in the carbon cycle, the key parameter is the amount of carbon sequestered by each million hectares of the earth's forests, **carforst**. By default, this coefficient is set to 0.12—meaning that every million hectares of forest sequesters 0.12 billion tons of carbon. By increasing or decreasing the value, users can explore futures in which forests are more or less effective at removing carbon from the atmosphere.

Parameters Affecting Water Resources

Parameter	Variable of Interest	Description	Type
watres	GOVRISK, THREAT	Renewable water resources	Exogenous specification
ylm	YL	Agricultural yield multiplier	Multiplier
watdemandelas	WATDEMAND	Elasticity from water price to water demand	Elasticity
landirareaequipelas	LANDIRAREAACTUAL	Elasticity from water price to land equipped for irrigation	Elasticity
desali	WATERDESALINATED	Desalination responsiveness to change in stock levels of price	PID factor
desald	WATERDESALINATED	Desalination responsiveness to change in price	PID factor

Watres allows users to set the renewable resources located in each of the countries in IFs. Changes to this parameter or exogenous variable can either be instantaneous or gradual, as specified by the user. Though each country's renewable water resources, and associated water stress, has bearing on state fragility, it is important to note that the **watres** parameter does not constrain water use. Users can manipulate the elasticity of water demand to water prices through the parameter **watdemandelas.** Similarly, users can change the elasticity of water

price to land equipped for irrigation using the parameter **landirareaequipelas.** Moreover, user can change the responsiveness of desalination to water prices through two parameters **desali** and **desald** that affect the integral and the differential factors on the PID formulation.

Users can affect water use via deeper drivers. Any increase (or decrease) in crop land, and subsequent increases (or decreases) in production, will require a corresponding change in water usage (**WATUSE**). Water usage per capita is linked to crop production per capita by a function in the model (Crop Production/Capita Versus Water Use/Capita). Thus, changing that function or manipulating the land growth by type parameter, **tgrld**, can trigger patterns of water uses differing from those featured in the Base Case. The yield multiplier **ylm** provides a very direct method of indirect water use modification; increases in production will require more water, often (implicitly in the model) through irrigation.

Parameters Affecting Air Pollution

Parameter	Variable of Interest	Description	Type
envpm2pt5m	ENVPM2PT5	PM2.5 levels multiplier	Multiplier
ensolfuelm	ENSOLFUEL	Solid fuel use multiplier	Multiplier
ensolfuelsetar	ENSOLFUEL	Solid fuel use SE target	Standard error target
ensolfuelseyrtar	ENSOLFUEL	Solid fuel use SE target	Standard error target
ensolfueltrgtval	ENSOLFUEL	Solid fuel elimination target	Target
ensolfueltrgtyr	ENSOLFUEL	Solid fuel elimination target	Target
hlsolfuelsw	DEATHCAT	Relationship between solid fuel and respiratory diseases	Switch

Several environmental parameters allow users to directly manipulate levels of air pollution. Fine grain aerial particulate matter levels in residential areas (**ENVPM2PT5**) are controlled by a multiplicative parameter, **envpm2pt5m**. Like any multiplier, assigning higher or lower values will result in a proportional change in the associated variable—in this case **ENVPM2PT5**. As an alternative, users can explore variations of solid fuel use in a specific country, region, or the world as a whole. The percentage of a population using solid fuel as their primary source of electricity (**ENSOLFUEL)** is connected to a multiplier, **ensolfuelm**. The model also features a pair of standard error target parameters: one that establishes the target, **ensolfuelsetar**, and one that establishes the year by which the target will be reached, **ensolfuelseyrtar**. Users can alternatively (not simultaneously) utilize a second pair of parameters to set a year by which solid fuel use will be either reduced, or eliminated completely. **Ensolfueltrgtval** sets the desired reduction, and **ensolfueltrgtyr** sets the target year. Finally, and related to forward linkages, users can control whether there is a relationship between the burning of solid fuel and health. When the switch parameter **hlsolfuelsw** is set to 1 (the default), a positive relationship between solid fuel use and respiratory disease is active; when the switch is set to 0, the relationship is deactivated.

Parameters Affecting climate change impact on the economy

Parameter	Variable of Interest	Description	Type
climeconimpsw	**CLIMECONIMP**	Climate change to economy impact switch (1=on)	Switch

climeconimplin	**CLIMECONIMP**	Climate change to economy impact, linear term coefficient	Co-efficient
climeconimpsq	**CLIMECONIMP**	Climate change to economy impact, squared term coefficient	Co-efficient
climeconimpstk	**VADD**	Climate change to econ impact, portion affecting productivity or capital stocks	Multiplier

Climate change impacts are fed forward to the economy through three parameters. **climeconimpsw** is a switch when turned initiates the computation of the impact of climate change on the economy. The impact is calculated through a quadratic formulation which was initially developed by Nordhaus. Accordingly, two co-efficients, **climeconimplin** and **climeconimpsq** compute the linear and the quadratic impact of climate change on the economy through an impact on Value added (VADD). **climeconimpstk** calculates the economic impact of climate change on capital stocks.

Prepackaged Scenarios

Exploring an alternative scenario conceptualized by the Netherlands Environmental Assessment Agency (PBL) can give users a quick overview of some of the powerful leverage points in the environment module. Using their integrated assessment model, called IMAGE, PBL constructed a set of forecasts representing a future in which carbon emissions drop dramatically. A replication of this scenario comes pre-packaged with the IFs installation, in the World Integrated Scenario Sets folder and the NCAR IPCC subfolder, under the title IMAGE_hirenew_lowcarbon. The folder contains, in total, five scenarios, all of which were developed during the course of a joint project between the Pardee Center and the National Center for Atmospheric Research (NCAR), which is located in Boulder, Colorado. Each alternative scenario uses IFs parameters to approximate work done by another integrated assessment model: BPL's Integrated Model to Assess the Global Environment (IMAGE), Asia-Pacific Environment Innovation Strategy's AIM, the International Atomic Energy Agency's MESSAGE, and Pacific Northwest National Laboratory's Mini-Climate Assessment Model, or MiniCAM.

In order to simulate a significant reduction in global carbon emissions, the IMAGE_hirenew_lowcarbon scenario includes interventions in capital-output ratio, fossil fuel burning behavior, and carbon tax policy. For oil, gas, coal and nuclear production in every country, the parameter **qem** is set to rise steadily, reaching a value of four by mid-century and remaining there until 2100. Conversely, the capital cost of each unit of renewable energy produced in the world is set to decline, with **qem** approaching 0.3, and remaining at that value until 2100. As fossil fuel production becomes expensive and green energy becomes relatively cheaper, price signals will push global energy producers to reduce carbon emissions. The use of the **carbtax** parameter augments the economic incentives attached to renewables in the scenario. By 2100 a carbon tax of 400 billion U.S. dollars is in place in every country in the world. Finally, the scenario adds an element of environmentally friendly technological change, through a reduction in the parameters **carfuel1**, **carfuel2**, and **carfuel3**. This would simulate worldwide discoveries allowing for the cleaner burning of oil, natural gas, and coal.

Governance Module

Variables of Interest

The IFs governance module contributes to a growing body of work dedicated to quantifying the performance of governments around the world. The IFs model adds to that literature especially by facilitating forecasting and scenario analysis. The module represents governance as a composite system, made up of three interconnected dimensions: security, capacity and inclusiveness. The modelling process builds on a large number of data series and governance indices constructed by various research groups, mostly in academia, non-profit organizations, and international organizations. Variables capturing regulatory quality and government effectiveness, for example, come from the World Bank's World Governance Indicator project; Freedom House and Transparency International provide measures of economic freedom and corruption; and the Center for Systemic Peace provides state fragility and democracy indicators. Based on such data and series, the IFs system builds up to aggregate indices for its three dimensions of governance: **GOVINDSECUR** for security, **GOVINDCAPAC**

Variable Name	Description
GOVINDSECUR	Governance security index
GOVINDCAPAC	Governance capacity index
GOVINDINCLUS	Government inclusiveness index
GOVINDTOTAL	Total governance index
SFINTLWARALL	Internal war, event occurrence
SFINTLWARMAG	Internal war, magnitude
GOVRISK	Government risk index
GOVREV	Government revenues
AID	Foreign Aid
GOVCORRUPT	Government Corruption
REGQUALITY	Regulatory quality
ECONFREE	Economic freedom measure
GOVEFFECT	Government effectiveness
DEMOCPOLITY	Level of democracy
FREEDOM	Freedom measure
GEM	Gender empowerment measure

for capacity, and **GOVINDINCLUS** for inclusivity. These three indices are then combined into an overall governance index, **GOVINDTOTAL**.

The building blocks of the three indices, however, are sub dimensions and component variables. Security's sub-dimensions are the probability of intrastate conflict (**SFINTLWARALL**) and a general level of government performance with associated risk of instability (**GOVRISK**). Although not used in the security index, **SFINTLWARMAG** supplements **SFINTLWARALL** by forecasting the average magnitude of internal conflict.

Forecasts of intrastate war probability (**SFINTLWARALL**) are heavily path dependent, driven by a moving average of countries' past experiences with violence. Over time, however, other factors—infant mortality, level of democracy, economic growth rate, and trade openness, among others—affect the probability of conflict as well. IFs uses an index, **GOVRISK**, to measure the second sub-dimension of security, government performance and associated risk. For the 186 countries included in the model, the overall index value ranges roughly from 15 to 60, with a higher number signifying increased levels of risk. Low risk countries such as Sweden will generally fall at the bottom of the range, while high risk ones such as Somalia will be at the top. Like the probability of war, each country's performance risk profile is driven by an array of factors across demographic, environmental, economic, health and education subsystems. A comprehensive look at each country's performance and risk profile is available through Specialized Display under the option Performance Risk Evaluation. The display includes raw values and a global ranking, for each of the index's nine components. Weighting and relative risk levels associated with each component are also listed.

The sub-dimensions of the second dimension of governance, capacity, are government revenue and government quality. Each country's ability to raise revenue is captured by a simple ratio of **GOVREV** to **GDP**—net of foreign aid (**AID**) received by governments, which the index does not include. The more revenue a government is able to raise relative to GDP, the higher the capacity score will be—for a discussion of the equilibrating processes used to calculate government revenue, expenditure and transfer payments see the [economic module](#). Governance quality, capacity's second sub-dimension, is represented by corruption. In the model, **GOVCORRUPT** measures relative levels of political corruption, with 0 representing extremely corrupt practices, and 10 representing extreme transparency, or lack of corruption. Indices tracking regulatory quality (**REGQUALITY)**, economic freedom (**ECONFREE)**, and government effectiveness (**GOVEFFECT)** offer alternative formulations of governance quality. Although the **GOVCORRUPT** score is the only element used to generate the composite index **GOVINDCAP**, the other indicators link forward to economic and infrastructure development processes.

The third dimension of governance, inclusiveness, is made up of the level of formal democratization and an element that measures gender empowerment in society. The **DEMOCPOLITY** index represents the strength of democratic institutions; in IFs, values range from 0 to 20, higher numbers signifying greater levels of democracy. In forecast years, several factors—the age structure of society, dependence on raw materials, energy exports and energy price—determine the strength of democracy. The model uses the gender empowerment measure (**GEM**) as another index of inclusiveness. The measure takes its historical values—and its name—from the United Nations Development Program's Gender Empowerment Measure. Forecasts of gender empowerment are driven by a country's youth population size, GDP per capita at purchasing power parity, and years of formal education attained by female adults. The index **FREEDOM**, created by Freedom House, offers a final formulation of civil participation in society. This measure is not used to generate the aggregate inclusiveness index, but it links forward to the social capital component of multifactor productivity.

While the three dimensions represent distinct facets of governance, they are tightly interrelated. Indeed, the drivers of security, capacity and inclusion often overlap. For example, gender empowerment, a sub-dimension of inclusion, drives security's vulnerability to conflict index and capacity's corruption index. And the three composite indices—**GOVINDSECUR, GOVINDCAPAC** and **GOVINDINCLUS**—interact bi-directionally with each other. Beyond the sub-module, strong relationships link the key governance indices and other measures of human well-being, represented by GDP per capita and the Human Development Index (HDI). For instance, economic freedom (**ECONFREE**) links forward to multifactor productivity (**MFP**) and thus on to broader economic growth. And conversely, other systems affect governance forecasts, as evidenced by the relationship between levels of per capita income and **HDI** and **DEMOCPOLITY**—higher levels of well-being lead to increased pressure for democracy.

The tri-part conceptualization of governance originated in the Pardee Center's analysis of historical trends, as discussed in *Potential Patterns of Human Progress*: *Strengthening Governance Globally (*Hughes et al. (2014)). Over time, the story of governance has unfolded differently in countries across the world—some countries have developed security, capacity and inclusiveness sequentially, and some countries have developed all three dimensions simultaneously. A suite of parameters attached to the sub-dimensions of each dimension allows users to explore a range of potential patterns of global governance.

Parameters to Affect Security

Parameter	Variable of Interest	Description	Type
sfusehist	N/A	State failure switch to use history for base values(0=off; 1=on; 2=converge)	Switch
sfintlwaradd	SFINTLWARALL	State failure/internal war addition	Additive
sfconv	SFINTLWARALL	State failure convergence	Convergence speed (years)
sfmassrep	SFINTLWARALL	State failure – Internal war repression by government	Switch
wpextinterv	SFINTLWARALL	External intervention factor	Switch
govriskm	GOVRISK	Government risk multiplier	Multiplier
govriskweight	GOVRISK	Government risk weight	Weight

The most direct way in which to change the probability of internal war, and thus its broader consequences, is to manipulate the additive parameter affecting the variable, **sfintlwaradd**. Other parameters connected to internal war and the country performance risk evaluation allow users to explore alternate scenarios around security. Over time, a country's probability of internal war will converge to the model's expected function, a function driven by demographic and economic factors. However, users can control the speed of convergence through the parameter **sfconv**—accelerating this convergence would be an effective way to improve the fortunes of countries with especially bad histories of intrastate violence, because path dependency is a driver of internal war probability. Though set to 0.0 in the Base Case, two additional parameters exist that can directly affect the likelihood of internal war. **Wpextinterv** is a parameter that, when activated, simulates a conflict-creating external intervention; when the parameter is set to 1.0 the probability of intrastate conflict rises to 1.0 also. Another parameter, **sfmassrep**, works in a similar way but with a reverse valence. Assigning it a value other than 0.0 simulates a campaign of mass repression by the central government that lowers the probability of overt intra-state violence.

Turning to government performance and risk evaluation, the multiplier **govriskm** directly controls the overall risk index, **GOVRISK**. Changes to the risk profile link forward to the higher order **GOVINDVSECUR** index, which in turn links to the overall governance score captured in **GOVINDTOTAL**. Users can also experiment with different risk configurations of a country or region via **govriskweight**; as the name implies, this parameter sets the weighting of **GOVRISK**'s component parts. As a final option, users can tailor their interventions to the components' values, rather than simply the weighting. Any of the government risk index's determining factors can be manipulated. The list of potential intervention targets includes: youth bulge, the ratio of water use to renewable resources, climate change, resource export dependence, rate of per capita GDP growth, infant mortality, life expectancy, malnutrition, HIV prevalence rate, primary net enrolment and adult education years. Scenario interventions could target one of these elements or several, cutting across IFs modules.

Parameters to Affect Capacity

Parameter	Variable of Interest	Description	Type
govrevm	GOVREV	Government Revenue Multiplier	Multiplier
firmtaxrm	GOVREV	Firm tax rate multiplier	Multiplier
hhtaxrm	GOVREV	Household tax rate multiplier	Multiplier
ssweltaxrm	GOVREV/SSWELTAX	Social Security and welfare tax rate multiplier	Multiplier
indirecttaxrm	GOVREV	Indirect tax rate multiplier	Multiplier
govcorruptm	GOVCORRUPT	Corruption Multiplier	Multiplier
govcorruptsetar	GOVCORRUPT	Corruption target	Standard error target
govcorruptseyrtar	GOVCORRUPT	Corruption target	Standard error target
goveffectm	GOVEFFECT	Effectiveness multiplier	Multiplier
goveffectsetar	GOVEFFECT	Effectiveness target	Standard error target
goveffectseyrtar	GOVEFFECT	Effectiveness target	Standard error target
govregqualm	GOVREGQUAL	Government regulatory quality multiplier	Multiplier
govregqualsetar	REGQUALITY	Regulatory quality target	Standard error target
govregqualseyrtar	REGQUALITY	Regulatory quality target	Standard error target
econfreem	ECONFREE	Economic freedom multiplier	Multiplier

The governance module includes parameters connected to both sub-dimensions of capacity: government revenue and government effectiveness. **Govrevm** is a direct multiplier of government revenue, **GOVREV**; assigning values to this parameter would signify either growing or diminishing government capacity to gather revenue. However, various, more nuanced, government revenue collecting programs can be simulated via several taxation parameters. The module includes multipliers to the tax rate paid by firms (**firmtaxrm**) and households (**hhtaxrm**), taxes paid on social security (**ssweltaxrm**) and indirect taxes such as sales tax or value added tax (**indirecttaxrm**). For a full discussion of government revenue interventions see the economic module discussion.

Each of the components of government effectiveness represents a potential target for scenario intervention. The variable **GOVCORRUPT**, measuring corruption levels, is connected to a multiplicative parameter, **govcorruptm**. Although corruption is the only representation of effectiveness tied to the **GOVINDCAPAC**, users may wish to explore the consequences of changes to other measures. Multipliers **govregqualm** and **econfreem** directly control the level of a country's regulatory quality (**REGQUALITY**) and economic freedom (**ECONFREE**). Increases to regulatory quality link forward to broadband connectivity and other information and communication technology (ICT) indicators; and changes in economic freedom affect multifactor productivity through social capital. Finally, users can manipulate the **GOVEFFECT** variable, a formulation of effectiveness taken from the World Bank's World Governance Indicators project. **Goveffectm** is a straightforward multiplier, with assigned values acting to scale effectiveness up or down.

Users can alternatively choose to manipulate governance quality indicators via standard error targeting. Two parameters are linked to each corruption, regulatory quality and effectiveness. The first parameter sets the target increase or decrease in the index, expressed in standard errors away from the expected function, and the second parameter sets the number of years that will pass before the target is reached. These parameters are

govcorruptsetar and **govcorruptseyrtar** for corruption, **govregqualsetar** and **govreqqualseyrtar** for regulatory quality, and **goveffectsetar** and **goveffectseyrtar** for government effectiveness.

Parameters to Affect Inclusiveness

Parameter	Variable of Interest	Description	Type
democm	DEMOCPOLITY	Democracy level multiplier	Multiplier
swseffects	DEMOCPOLITY	Swing state effect	Switch
democimpus	DEMOCPOLITY	Democracy impetus by leading power	Coefficient
democimpoth	DEMOCPOLITY	Democracy impetus by other powers	Coefficient
DEMOCWDIR	N/A	Democracy wave direction (-1=down; 0=off; 1=up)	Switch
democwvlen	DEMOCPOLITY	Democracy wave length in years	Limit
democwvmax	DEMOCPOLITY	Democracy wave upper limit	Limit
democpolitysetar	DEMOCPOLITY	Democracy SE target	Standard error target
democpolityseyrtar	DEMOCPOLITY	Democracy SE year	Standard error target
freedomm	FREEDOM	Freedom multiplier	Multiplier
gemm	GEM	Gender empowerment multiplier	Multiplier
gemsetar	GEM	Gender empowerment target	Standard error target
gemseyrtar	GEM	Gender empowerment year target	Standard error target

The two sub-dimensions of government inclusiveness are democracy and gender empowerment. Users wishing to explore alternative scenarios around levels of democracy can choose from an array of leverage points. First, the multiplier **democm** allows direct manipulation of the variable **DEMOCPOLITY** for a country or region. Users choosing this brute force method should direct their attention to linkages in multifactor productivity, state fragility, and the overall **GOVINDINCLUS** index. Scenario interventions could also target any of the deeper drivers of democracy. In the model, forecasts of democracy levels are a function of gender empowerment, the youth bulge, dependency on raw material exports and energy prices. Two other parameters—disabled in the base case—can affect **DEMOCPOLITY**. The first simulates a neighborhood affect: if **swseffects** is set to a value of 1, swing states in a geographic region will be pressured to conform to their neighbors' democratic practices—or lack thereof. The second additional method is rather complicated and will not be of interest to most users. The variable **DEMOCWAVE** either adds to or subtracts from the democracy levels determined by the model, simulating a wider neighborhood, in fact global, effect known as a wave of democracy. The magnitude of upswings or downswings is specified exogenously through several parameters: **democimpus,** the impetus provided to democracy by the leading power; **democimpoth**, the impetus provided to democracy by other powers; **democwvlen**, the wave of democracy's duration in years; and, **democwvmax**, the maximum rise in democracy levels. When a democracy wave is active, two variables track the process: **DEMOCWVCOUNT** measures the duration of the wave's run and recession, and **DEMOCWVDIR** contains the direction of the wave, whether it supports or hinders the consolidation of democracy. As an alternative to other types of intervention, users may override the polity function through the use of external targeting. **Democpolitysetar** specifies a standard error target, and **democpolityseyrtar** specifies the year in which this target will be achieved.

The degree of civilian participation – on the part of all citizens – is another driver of inclusiveness. Whereas the polity measure of democracy (**DEMOCPOLITY**) measures formal, electoral inclusion, the variable **FREEDOM** is a

more comprehensive measure of civil participation. **FREEDOM** is computed from levels of GDP and general educational attainment—among both men and women; and like the other elements inclusion, it is linked to a brute force multiplier, **freedomm**. Unlike the other parameters, however, standard error targeting is not available for the civil society freedom variable.

The second dimension of government inclusiveness, gender empowerment, offers a final target for scenario analysis. The three primary drivers of the gender empowerment measure (**GEM**) are youth bulge size, GDP per capita at purchasing power parity, and years of formal education obtained by females over age fifteen. Users can build alternate scenarios around a combination of driving factors, or, more directly, through a multiplicative parameter. The multiplier **gemm** allows users to directly control the progression/regression of gender empowerment in a country or region. Additional parameters control standard error targeting around **GEM**: used together, **gemsetar** and **gemseyrtar** establish a target value, measured in distance from the expected, cross-sectional function, and the time required to reach the target.

Prepackaged Scenarios

An installation of IFs includes scenarios used in each entry in the Pardee Center's Potential Patterns of Human Progress (PPHP) series. Scenarios created for the governance volume include: a high conflict scenario; a scenario representing challenges to the world's governments; a set of scenarios that speed up economic growth via multifactor productivity; and, finally, a set of government strengthening scenarios. This section will briefly describe the parameter interventions used to construct several of the enhanced government scenarios, located in the folder Strengthened Governance.

The collection of governance scenarios includes one scenario for each of the three dimensions: Strengthened Security, Strengthened Capacity SE1 and Strengthened Inclusiveness SE1. Each scenario includes a single parameter shift that targets one sub-dimension of security, capacity, or inclusion. Users wishing to load the three interventions simultaneously can select the combined scenario, Strengthened Governance SE1. The boost to capacity operates through **govrevm**, the multiplier tied to the revenue sub-dimension of capacity; the parameter is set to 1.1 for the majority of the forecast horizon, raising revenue collection each year. The intervention in inclusion targets the democracy sub-dimension. For the entire forecast horizon, from 2010 to 2100, **democpolitysetar** is set to 1, establishing an improvement target in democracy levels of one standard error. As the corresponding year parameter, **democpolityseyrtar**, is not changed, it takes on its default value of 10.0. This means that the target of one standard error will be reached in 10 years. The final intervention simulates a decline in intra-state violence the world over. The additive factor **sfintlwaradd** interpolates from 0 to -1 over thirty years; after reaching negative 1, it remains at that value through 2100.

The final scenario in the governance set, Strengthened Policies, features interventions to deeper drivers of each governance dimension, including: educational improvements at primary, lower secondary, upper secondary and tertiary schooling levels; reductions in childhood malnutrition; increased government transfers and international development assistance; steady decline in total fertility rates across western, central and eastern Africa as well as Oceania; rising agricultural yields; less solid fuel use, and a corresponding reduction in atmospheric particulate matter.

The two comprehensive scenarios contained in the PPHP Governance folder represent distinct methods of alternative forecast analysis. Strengthened Governance SE1 explores the effects of directly manipulating governance indicators. Strengthened Policies, on the other hand, explores the forward linkages of governance drivers.

International Politics Module

Variables of Interest

Unlike other systems, such as demographics or economics, there is no standard organizational structure used to represent international politics. In order to establish a theoretical structure that describes interactions between states, IFs draws on in-house expertise, as well as work conducted by other research organizations, academics and governments and, of course, international relations theory and empirical work. The two foundational elements in the model are power and threat levels, which trigger alliances, conflicts and military spending. IFs takes conceptual and theoretical inputs from projects that have been dedicated to quantifying power and threat dynamics, including J. David Singer's Correlates of War project, initiated at the University of Michigan, which produced the Composite Index of National Capability (CINC) –a measure of hard power, the CINC formulation includes demographic, economic and military components. IFs reaches out for data to a variety of sources including the Stockholm International Peace Research Institute's (SIPRI) datasets on military expenditures, arms trade, and international conflicts. The IFs international politics module contributes to existing work in the field by forecasting measures of hard power and of threat levels between states. It is increasingly also developing data and forecasting capability around diplomacy.

IFs includes several formulations of power. The variable **POWER** is an index, computed in the model, that measures each country's share of world power. The index is comprised of weighted

Variable Name	Description
POWER	Total power index
CPOW	Conventional power
NPOW	Nuclear power
WCPOW	World conventional power
WNPOW	World nuclear power
PCONGREAT	Power concentration of great powers
PCONGREATEU	Power concentration of great powers, single Europe
PCONGREATEUF	Power concentration of great powers, flexibly defined, with single Europe.
THREAT	Probability of militarized conflict
THREATREC	Threat received
THREATSENT	Threat sent
WGDP	World GDP
WTRADE	World trade
GOVEMBED	Government embeddedness
CWAR	Conventional war
CWARPB	Conventional war probability
NWAR	Nuclear war
NWARPB	Nuclear war probability
CIVDM	Civilian damage (multiplier)
DEMOCPOLITY	Level of democracy
DIPLOEMBASSY [10]	Number of embassies held in other countries
DIPLOIGO	International organization membership
DIPLOTREATY	Treaty participation

elements for: GDP, population, GDP per capita (as a proxy for technological sophistication), government size, public military spending, conventional power, and nuclear power. Levels of conventional (**CPOW**) and nuclear (**NPOW**) power have their own dynamics, but both are primarily dependent on military spending patterns, as captured in the variable **GDS** and an associated parameter that determines the amount of funding available for nuclear weapons research. (For a full discussion of government spending flowing to the military and to other destinations, see the economic section.) **NPOW** is not an index – like **POWER** or **CPOW** – but rather the number of nuclear warheads owned by each country. Two additional variables measure global power. The indicator of the

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[10] For **DIPLOEMBASSY, DIPLOIGO** and **DIPLOTREATY**, there exist three corresponding variables with the suffix **MAX** that cap forecast values.

world's stock of nuclear power, **WNPOW**, is measured in megatons. And **WCPOW** is an aggregate value of all countries' conventional power, expressed as an index.

Depending on the configuration of power at a given point in time, the international system may be multipolar, bipolar, or unipolar. A set of variables in the model capture the degree to which power is concentrated in the hands of a few nations. The index **PCONGREAT** measures the percentage of global power held by dominant, or great powers— as values approach zero, smaller shares of power would be held by so-called great powers. **PCONGREATEU** measures the percentage of global power held by great powers, considering the European Union to be a single actor. **PCONGREATEUF** measures the percentage of global power held by great powers, with the European Union considered a single actor and the category "great power" flexibly defined; the flexible definition refers to the phasing in of great power status above a threshold share of global power up to full great power status upon attaining a higher share. And finally, the variable **PCONSYS** is an index indicating the power concentration of the global system, regardless of the number of great powers.

In IFs, the balance of power between actors in the international system links forward to threat (**THREAT**) of militarized interstate disputes (MIDs). The model calculates the threat that any state poses to any other state as a product of historical conflict data and a predictive function. Three especially important factors drive the dyadic function: contiguity, whether or not either of the countries is a great power, and the existence of a territorial dispute between the countries. Additional drivers of international threat include world trade (**WTRADE**), energy production (**WENP**), and strength of democracy (**DEMOCPOLITY**). We also compute a level of government embeddedness (**GOVEMBED**) that may interact with power structures in future model development. (Government embeddedness is a concept taken from international political economy; a government is considered embedded if its actions are constrained by domestic institutions, firms and households). The results of computations are stored in an index, **THREAT**, which can be interpreted very roughly as the probability that a pair of countries will experience a militarized dispute in a given year (but expressed in percentage terms of 0-100 instead of probabilistic ones of 0-1). Countries can be theorized as both recipients and deliverers of threat: **THREATREC** is of the total of all threat received from all senders; **THREATSENT** is, as the name indicates, the total threat sent by a country. And the variable **WTHREAT** is an average of threat levels between all country pairs, thus offering an indication of global military tension.

The model includes a specialized display for threat dynamics and other dyadic (country-to-country) interaction. To access the display select the Data Analysis option from the IFs main menu, then select Dyadic Interaction Display. On the resulting form, users can explore the relationship between any two countries via the list boxes labeled CountryA and CountryB. In addition to **THREAT**, a slew of international political variables are available for dyadic display in the Variable box: Midpresent, FatalityBinary, StandAlliance, StandDiplo, StandGO, Stand UN, StandTrade, StandCOI, StandLiberalisHigherMoreLib, StandRealismLowerMoreTension.

As an additional feature, the international politics module includes an optional war simulation. When the war option is activated, the model will stochastically (randomly) introduce a war, based on dyadic threat levels described above. The variables **CWARPB** and **NWARPB** measure the probability that a conventional or nuclear war will break out in a given year, whether or not the switch for the war option is activated. When the switch is on, a second pair of variables identifies the occurrence or absence of conventional war and nuclear war: **CWAR** and **NWAR** take on binary values, 1 indicating the presence of war, and 0 indicating the absence of war. Once a war event takes place, the countries involved will experience fatalities and material damage. **CIVDM** tracks the human costs to overall population and the capital lost in the fighting.

In addition to forecasting power, threat and conflict, the IFs model forecasts several diplomatic measures. The model currently includes variables containing the number of embassies each country has abroad (**DIPLOEMBASSY**), international organization membership (**DIPLOIGO**), and treaty membership (**DIPLOTREATY**). Like the other variables in IFs, these measures of soft power are forecast out to 2100 for each country.

Parameters in the international politics model allow users to create alternative scenarios that explore uncertainty around the international power structure, dyadic threat levels, the outbreak of war, and diplomacy.

Parameters Affecting Power

Parameter	Variable of Interest	Description	Type
cpowf	CPOW	Factor controlling military spending conversion	Convergence factor
cpowldcf	CPOW	Higher impact of military spending in LDCs	Convergence factor
drcpow	CPOW	Depreciation rate of conventional power	Rate of change
cpowdf	CPOW	Conventional power, damage done by war	Coefficient
govnucwpadd	NPOW	Nuclear weapons stockpile change	Additive factor
wpwghtpow	POWERHH	Contribution of various components to power index	Index weight
wpgreatthresh	PCONGREAT	Systemic power share required for threshold of great power status	Coefficient
wpgreatlev	PCONGREAT	Systemic power share required for full great power status	Coefficient
wpconmax	PCONGREAT	Maximum power concentration	Limit
wpconmin	PCONGREAT	Minimum power concentration	Limit

A suite of parameters is available to users who wish to explore power dynamics in the IFs model. Conventional power (**CPOW**) can be manipulated using the parameters **cpowf**, **cpowldcf**, and **drcpow**. The first controls the elasticity between military spending and conventional power accrual; higher values of **cpowf** increase the impact that military spending has on conventional power measures. **Cpowldcf** controls the impact of military spending within LDCs, where military spending has historically had a greater impact on measures of power, largely because the costs of military personnel are lower. And **drcpow** controls the depreciation rate of conventional power. This parameter controls the rate at which past investments in conventional power decline as a contribution to power in successive years. The destructiveness of interstate conflict has a negative impact on conventional power measures. The impact that conventional war has on combatant nations, as measured by **CIVDM**, can be controlled by **cpowdf**—the higher the parameter value, the greater the civilian deaths and capital destruction. Users may also increase or decrease a country's stock of nuclear weapons via the parameter **govnucwpadd**. Nuclear weapons capacity influences total power through the nuclear power component, **NPOW**.

The aggregate measurement of power is similarly connected to parameter levers. The parameter **wpwghtpow** allows users to customize the set of weights used in the calculation of the power index (**POWER**). Individual weights are attached to each of the index's components: population, GDPatPPP, GDP, GDPxGDPPCatPPP, GDPxGDPPC, Govt, MilSpend, ConvPow, NucPow, NucWarHeads, EnergyNetExport, TradeTotal, FDIInflows, AidNet, HumCapWkPopHDI, GovRev, InnovationR&D, and ConnectivityICTProd.

Users can also alter the role of great powers in the international political system. **Wpgreatthresh** controls the threshold level of the power index that, when achieved, signals the basic level of a nation's transition into (or out of) being a great power. **Wpgreatlev** controls the power share held by full great powers, allowing users to model greater or lower levels of power diffusion. And, **wpconeusw** is a switch parameter that controls whether the EU is considered a single great power in the global power structure.

Two final parameters place limits on the levels of power that any country can experience. **Wpconmax** and **wpconmin** set the maximum and minimum level of power that a country can reach in forecast years.

Parameters Affecting Threat Levels

Parameter	Variable of Interest	Description	Type
wpgreat1	THREAT	Dyadic dispute probability, one great power	Coefficient
wpgreat2	THREAT	Dyadic dispute probability, two great powers	Coefficient
wppowtran1	THREAT	Power transition threshold	Coefficient
wppowtran2	THREAT	Increase in dispute probability with 10% greater power parity	Elasticity
wpcon	THREAT	Change in threat with power concentration	Coefficient
wpconsq	THREAT	Change in threat with power concentration	Coefficient
wpcontiguity	THREAT	Threat associated with geographic proximity	Elasticity
wpdemdist	THREAT	Response of threat to political distance	Elasticity
wpdemmin	THREAT	Response of threat to the minimum democracy level in the dyad	Limit
glocom	THREAT	Global community multiplier	Exogenous specification
wpcommun	THREAT	Response of threat to global community level	Elasticity
wptrade	THREAT	Change in threat with systemic trade	Elasticity
ally	THREAT	Alliance membership switch	Switch
wpally	THREAT	Reduction in threat with allied dyad	Elasticity
terdispute	THREAT	Territorial dispute or absence	Exogenous specification
wpterdisp	THREAT	Conflict arising from territorial disputes	Elasticity
wpthrconv	THREAT	Threat level convergence	Convergence Speed

All parameters modifying threat affect the same variable, probability of dyadic conflict (**THREAT**). **Wpgreat1** and **wpgreat2** specify the likelihood of disputes involving one and two great powers, respectively. The reason these parameters exist is that great powers have historically been much more likely to experience conflict than have other states. A subset of great powers, namely the global leader in power and any power challenging that leadership and transition itself into system leadership, is especially likely to be engaged in conflict. **Wppowertran1** sets the dyadic power ratio for those two countries that identifies the beginning of a power transition and thereby triggers an increase in conflict threat levels. For example, a **wppowertran1** value of 0.7 means that a threat increase would begin once the weaker dyad member achieve a power score (**POWER**) equal to 70 percent of the more powerful member's score. **Wppowertran2** then establishes increase in the likelihood of conflict associated with increased power parity. More specifically, a **wppowertran2** value of 0.05 means that, once a power transition has begun, each further reduction in a dyad's power differential of 10 percent leads to an increase in threat levels of 5 percent.

Regardless of the number of great powers or the occurrence of a power transition, the concentration of power in the global system of great powers (PCONGREAT), as described earlier, can affect the level of threat of conflict (THREAT). Users may wish to take note of, **wpcon** and **wpconsq**, the two coefficients that control the relationship

between power concentration and conflict likelihood. Wpcon directly links concentration to threat and wpconsq links the square of power concentration to threat.

Several additional parameters relate to the probability or threat of conflict in a dyad . **Wpcontiguity** controls the threat of dispute generated by geographic proximity, one of the strongest determinants of conflict. **Wpdemdist** alters threat generated in response to political incompatibility—i.e., divergent levels of democracy—between two members in a dyad (the greater the distance, the greater the threat). **Wpdemmin** relates conflict to the democracy level of the less democratic member of a dyad (if democracy of that member rises, the default value of that parameter would lower threat). A pair of parameters together establish the relationship between the global community and threat. **Glocom** represents an exogenous specification of the cohesiveness of the global community, and **wpcommun** is an elasticity between international cohesion and the probability of conflict. **Wptrade** modifies the response of threat to the level of systemic trade. The parameter **ally** is a switch parameter that turns on or off alliance memberships, while the parameter **wpally** reduces the probability of dispute if two dyadic members are allied. And finally, **terdispute** defines the presence or absence of a territorial dispute within a dyad, while **wpterdisp** changes the likelihood of conflict arising from such disputes.

One other parameter is worth noting. **Wpthrconv** defines the convergence speed of historical threat levels within a dyad (which in initialization for the first model year reflect the reality of past conflicts) to the level of dyadic threat as calculated using all of the drivers and relationships indicated above. If that convergence speed, expressed in terms of the number of years for full convergence, is very slow (a high value for years needed), then the path dependency of past conflict will continue much more strongly to affect future likelihood than if the convergence speed is very fast (a low value for years).

Parameters Affecting War Simulation

Parameter	Variable of Interest	Description	Type
wpthrwar	CWARPB	Portion of disputes that escalate to war	Coefficient
waron	CWAR, NWAR	War switch	Switch
cwarbase	CWARPB	Conventional war probability addition to base computation	Additive factor
cwarf	CWARPB	Conventional war forcing	Switch
cwarsv	CIVDM	Conventional war severity	Multiplier
nwarf	NWARPB	Probability that conventional war will escalate to nuclear	Coefficient
cdmf	CIVDM	Civilian war damage factor	Multiplier
nwarsv	CIVDM	Nuclear war severity	Multiplier
elndpow	CIVDM	Elasticity of nuclear damage with nuclear power	Elasticity

Threat (**THREAT**) within a dyad is, as indicated above, related to the probability of conflict but not identical to it, because scaling of the various contributions to the threat variable is complicated and uncertain. The parameter **wpthrwar** translates threat within a dyad into a probability of conventional conflict (**CWARPB**) in that same dyad. There will never be an actual conventional war, however, unless the war switch is turned on (**waron**=1). When that switch is on and **CWARPB** for a dyad is non-zero, conventional war in any dyad-year occurs randomly in relationship to that war probability. For any given dyad-year a user can change the probability of conventional war

with the additive parameter **cwarbase**. Or wars can be forced with the parameter switch, **cwarf**, when it is set to 100 or above.

The probability of a nuclear war (**NWARPB**) is zero unless there is a conventional war (CWAR=1). If there is a conventional war, the probability of a nuclear war is determined by the severity of conventional war (**cwarsv**) and the probability of escalation (**nwarf**). If **nwarf** is set to 100 or above, it will force a nuclear war when a conventional one occurs between nuclear powers.

Once a conventional or nuclear war takes place, several parameters determine how damaging the effects will be. **Cdmf** is a multiplier that serves as a civilian war damage factor—the higher the parameter's value, the greater the casualties and physical destruction. Two related parameters, **cwarsv** and **nwarsv**, control the severity of conventional and nuclear war. **Elndpow** is an elasticity of nuclear war severity and nuclear weapon numbers.

Parameters Affecting Diplomacy

Parameter	Variable of Interest	Description	Type
diploembassymaxm	DIPLOEMBASSYMAX	Multiplier on maximum no. of embassies a country can have in another country in a given year	Multiplier
diploigomaxm	DIPLOIGOMAX	Maximum international organization membership for a country in a given year	Multiplier
diplotreatymaxm	DIPLOTREATYMAX	Multiplier on max standardized treaties that a country can sign/ratify in a given year	Multiplier

The diplomacy portion of the IFs international politics module is under development. Currently, three multiplicative parameters exist that allow users to manipulate forecast values of embassies abroad (**DIPLOEMBASSY**), international organization membership (**DIPLOIGO**) and bilateral treaty agreements (**DIPLOTREATY**). Forecast values of each measure of soft power are limited by cap variables— **DIPLOEMBASSYMAX**, **DIPLOIGOMAX**, and **DIPLOTREATYMAX**. Users can raise or lower these caps via the parameters **diploembassymaxm**, **diploigomaxm** and **diplotreatymaxm**.

Prepackaged Scenarios

There are few prepackaged scenarios which make use of the international politics parameters. Two sets featuring limited interventions are located under the Understandings of Causality heading in the Prepackaged Scenarios folder. Under the heading Power Capabilities are a number of different formulations of global power which modify the parameter **wpwghtpow**. These modifications are designed to reproduce the distributions of global power that have been discussed by academic researchers. For instance, the scenario COW-Like 3-Element at PPP increases the weighting for population, GDP at PPP, and military spending in the calculation of power. Three other scenarios in this folder (Brecke Formulation, Hillebrand-Herman Base and COW-Like 3-Element at Market) create alternative structuring of the POWER variable. Two other scenarios in this folder, Slow China Formulation, and Slow China Formulation with growth, model a slow growth in power for China by underweighting the value of military spending, GDP, GDPPPC, and population, while overweighting GDPPC.

In the folder labeled Threat International are two scenarios that model the threat of international war. These two scenarios modify the parameter **wpthrconv** in order to frame various assumptions about the dynamics of threats at the international level.

Finally, one scenario in the World Integrated Scenario Sets demonstrates the use of power parameters. This scenario is located in the MENA Scenarios and is called Iran Nukes + Sanctions. The scenario models the possible effect of Iran acquiring nuclear weapons and the potential US response. This scenario increases **govnucwpadd** to simulate the effect of Iran acquiring nukes, and then alters the calculation of the power index to underweight population, GDPPP, GDPxGDPPCatPPP, and military spending, while overweighting the effect of nuclear warheads, net exports of energy, trade flows, FDI inflows, net aid, government revenue, human capital, innovation and R&D, and connectivity of ICT. It also decreases exports (**xshift**), protectionism (**protecm**), oil and gas production (**enpm**), to demonstrate the possible impact of an international response that favored increasing sanctions against the country.

Parameter Dictionary

Population

Parameter	Variable of Interest	Description	Type
tfrm	TFR, CBR	Total fertility multiplier	Multiplier
contrusm	CONTRUSE	Contraceptive use multiplier	Multiplier
eltfrcon	TFR	Elasticity of total fertility rate to contraception use	Elasticity
tfrmin	TFR	Long term TFR convergence value	Limit
mortm	DEATHS	Mortality multiplier (not cause specific)	Multiplier
hlmortm	DEATHS	Mortality multiplier by cause	Multiplier
wmigrm	MIGRATE, MIGRANTS	World migration rate multiplier	Multiplier
migrater	MIGRATE, MIGRANTS	Net migration rate (inward)	Rate of change
migrateoutm	MIGRANTSOUT, MIGRANTS	Migration rate outward multiplier	Multiplier
migrateinm	MIGRANTSIN, MIGRANTS	Migration rate inward multiplier	Multiplier
workageentry	POPPREWORK, POPWORKING	Working age determinant	Exogenous specification
workageretire	POPWORKING, POPRETIRED	Retirement age determinant	Exogenous specification

Health

Parameter	Variable of Interest	Description	Type
hlmortm	DEATHCAT, HLYLL, HLDALY	Multiplier on Mortality (by cause)	Multiplier
hlmorbm	YLD	Multiplier on morbidity	Multiplier
hlstddthsw	DEATHCAT	Switches DEATHCAT from absolute numbers to deaths/1000	Switch
watsafem	WATSAFE, INFMOR	Percentage of population with access to safe water	Multiplier
sanitationm	SANITATION, INFMOR	Percentage of population with access to improved sanitation	Multiplier
malnelimstartyr	MALNPOP	Prevalence of undernutrition	Standard error target start year
malnelimtargetyr	MALNPOP	Prevalence of undernutrition	Standard error target year
malelimprecisesw	MALNPOP	Prevalence of undernutrition	Switch
ylm	YL	Yield multiplier on agriculture	Multiplier
hivm	HIVCASES	Rate of HIV infection	Multiplier
clpccvm	CLPCCV, MALNPOPP	Multiplier on coefficient of variation for calories per capita	Multiplier
envpm2pt5m	ENVPM2PT5	Increases levels of environmental pollution	Multiplier
hlsmokingm	HLSMOKING	Increases rate of smoking	Multiplier
hlobesitym	HLOBESITY	Prevalence of obesity	Multiplier
hlbmim	HLBMI	Multiplier on body mass index	Multiplier
deathtrpvm	DEATHTRPV	Multiplier on traffic deaths per vehicle	Multiplier

Parameter	Variable of Interest	Description	Type
deathtrpvsetar, deathtrpseyrtar	DEATHTRPV	Standard error target for traffic deaths per vehicle	Relative target Value/Year
hlmortmodsw	CDR	Reduces crude death rate in Africa, Europe, Southeast Asia, West Pacific	Switch
hltechshift	CDR	Rate of change in health technology	Additive factor
hltechlinc	CDR	Rate of change in health technology in low income countries	Additive factor
hltechssa	CDR	Rate of change in health technology in Sub-Saharan Africa	Additive factor
hltechbase	CDR	Rate of change in health technology at base	Exogenous specification

HIV/AIDS

Parameter	Variable of Interest	Description	Type
hivm	HIVRATE	HIV infection rate, multiplier of percent of population infected	Multiplier
hivtadvr	HIV CASES, HIVRATE	Technical advance rate in of control of infection	Rate of change
hivpeakr	HIVCASES, HIVRATE	HIV infection rate at year of peak	Target value
hivpeakyr	HIVRATE	Sets year of epidemic peak	Target year
hivincr	HIVCASES	HIV increase rate, only used prior to 2000	Rate of change
aidsdrtadvr	AIDSDTHS, AIDSRATE	AIDs death rate, technical annual advance rate in control	Rate of change
aidsdratem	AIDSRATE	AIDs death rate as % of HIV infection rate, multiplier	Multiplier

Severe Acute Malnutrition (SAM) Submodule

Parameter	Variable of Interest	Description	Type
malnchpadj	MALNCHPSAMINC	Used to adjust the incidence correction factor	Adjustment factor
malnchpsamm	MALNCHPSAM	Used to change prevalence of SAM	Multiplier
samadmissionadd	SAMADMISSION	Used to increase or decrease the number of admissions for treatment	Additive factor
samadmissionm	SAMADMISSION	Used to increase or decrease the number of admissions for treatment	Multiplier
samadmissionsw	SAMADMISSION	Allows users to forecast SAM admissions in three ways (0) forecasts all countries according to the relationship with GDPPCP, (1) holds all initial zero values constant over time (default value), and (2) holds all initial values constant.	Switch
samavertedconvyr	SAMAVERTED	Allows users to change the years to converge to 100	Convergence factor
samavertedm	SAMAVERTED	Allows users to change the number of averted cases	Multiplier
malnchpsamtostunt	MALNCHPSAM and HLSTUNT	Controls the degree to which MALNCHPSAM affects HLSTUNT	Adjustment factor
samrrsw	MALNCHPSAM and MALNCHP	Used to substitute the severity of MALNCHP with that of MALNCHPSAM	Switch

samtomalnchpsw	MALNCHP	allows users to specify scenarios in which successful treatment does not result in full weight	Switch

Education

Parameter	Variable of Interest	Description	Type
edpriintngr	EDPRIINTN	Primary net intake rate	Annual growth rate
edterintgr	EDTERINT	Tertiary intake rate	Annual growth rate
edseclowrtrangr	EDSECLOWRTRAN	Lower secondary transition rate	Annual growth rate
edsecupprtrangr	EDSECUPPRTRAN	Upper secondary transition rate	Annual growth rate
edprisurgr	EDPRISUR	Primary survival rate	Annual growth rate
edtergradgr	EDTERSUR	Tertiary survival rates	Annual growth rate
edpriintntrgtyr	EDPRIINTN	Primary net intake rate	Target
edseclowrtrantrgtyr	EDSECLOWRTRAN	Lower secondary transition rate	Target
edsecupprtrantrgtyr	EDSECUPPRTRAN	Upper secondary transition rate	Target
edterinttrgtyr	EDTERINT	Tertiary Intake Rate	Target
edprisurtrgtyr	EDPRISUR	Primary survival rate	Target
edtergradtrgtyr	EDTERGRAD	Tertiary graduation rates	Target
edpriintnm	EDPRIINTN	Primary net intake rate	Multiplier
edterintm	EDTERINT	Tertiary intake rate	Multiplier
edseclowrtranm	EDSECLOWRTRAN	Lower secondary transition rate	Multiplier
edsecupprtranm	EDSECUPPRTRAN	Upper secondary transition rate	Multiplier
edprisurm	EDPRISUR	Primary survival rate	Multiplier
edtergradm	EDTERGRAD	Tertiary survival rates	Multiplier
gdsm (education)	GDS	Government spending on education	Multiplier
edbudgon	GDS	Education funding priority	Exogenous specification
gdsedm	GDS	Education spending distribution	Multiplier
edexppconv	EDEXPERPRI	Education spending per student, primary	Convergence speed
edexpslconv	EDEXPERSEC	Education spending per student, secondary	Convergence speed
edexpsuconv	EDEXPERSEC	Education spending per student, secondary	Convergence speed
edexptconv	EDEXPERTER	Education spending per student, tertiary	Convergence speed
edqtqltrm	EDEXPERPRI, EDEXPERSEC , EDEXPERTER and GDS	Education quantity-quality balance	Multiplier
edprigndreqintn	EDPRIINTN	Gender parity for primary intake	Convergence speed
edprigndreqsur	EDPRISUR	Gender parity for primary survival	Convergence speed
edseclowrgndreqtran	EDSECLWRTRAN	Gender parity for lower secondary transition	Convergence speed
edsecupprgndreqtran	EDSECUPPRTRAN	Gender parity for upper secondary transition	Convergence speed
edtergndreqint	EDTERINT	Gender parity for tertiary intake	Convergence speed
edtergndreqgrad	EDTERSUR	Gender parity for tertiary survival	Convergence speed

Parameter	Variable of Interest	Description	Type
edqualpriallm	EDQUALAG15PRI	Multiplier on primary education learning quality	Multiplier
edqualsecallm	EDQUALAG15SEC	Multiplier on secondary education learning quality	Multiplier
edqualag15m	EDQUALAG15	Multiplier on total learning quality for adults	Multiplier
mfpedqual	TFP	Elasticity of education quality to multifactor productivity	Elasticity
edmodelsw	N/A	Education switch between old and new model (0=old model; 1=new model)	Switch
edpridrpgrdm	EDPRICR / EDPRIDRPGRD / EDPRIENRGGRD	Education, primary, grade-specific dropout rate, multiplier base 1	Multiplier
edprienrgrdm	EDPRICR / EDPRIDRPGRD / EDPRIENRGGRD	Education, primary, grade-specific enrollment rate, multiplier base 1	Multiplier
edseclowrdrpgrdm	EDSECLOWRDRPGRD/ EDSECLOWRENRGGRD/ EDSECLOWRTOT	Education, lower secondary, grade-specific dropout rate, multiplier base 1	Multiplier
edseclowrenrgrdm	EDSECLOWRENRGGRD/ EDSECLOWRTOT	Education, lower secondary, grade-specific enrollment rate, multiplier base 1	Multiplier

Economics

Parameter	Variable of Interest	Description	Type
labparm	LAB	Labor participation rate multiplier	Multiplier
labfemshrm	LAB	Female labor force participation rate multiplier	Multiplier
labretagem	LAB	Retirement age, labor force participation multiplier	Multiplier
labunemprm	LABUNEMPR	Labor unemployment rate multiplier	Multiplier
labmarketsw	LABS	Labor demand to economic production switch (1=on)	Switch
labdemsm	LABDEMS	Labor force, multiplier on demand	Multiplier
labcoeffsm	LABCOEFFS	Labor demand, multiplier on technology coefficients	Multiplier
workageentry	POPRETIRED	Age at which individuals enter the labor force	Exogenous specification
workageretire	POPRETIRED	Age at which individuals leave the labor force	Exogenous specification
invm	IDS	Investment by destination sector	Multiplier
mfpadd	MFP components	Multifactor productivity, additive	Additive factor
mfpleadr	MFP	MFP growth rate of the technological lead country	Growth Rate
mfpedspn	GDS-educ	Increase portion of spending going to education	Elasticity
malnelimstartyr	MALNPOP	Undernutrition elimination standard error target	Standard error target
malnelimtargetyr	MALNPOP	Undernutrition elimination standard error target	Standard error target
malelimprecisesw	MALNPOP	Undernourishment elimination	Switch

ylm	YL	Land yield	Multiplier
aginvm	AGINV	Investment in agriculture	Multiplier
ldcropm	LD(crop land)	Share of crop land in total land	Multiplier
econfreem	ECONFREE	Economic freedom	Multiplier
goveffectm	GOVEFFECT	Government effectiveness	Multiplier
govcorruptm	GOVCORRUPT	Government corruption	Multiplier
freedomm	FREEDOM	Freedom/democracy	Multiplier
mfpinfrindtrad	INFRAINDTRAD	Traditional infrastructure	Elasticity
mfpinfrindict	INFRAINDICT	ICT infrastructure	Elasticity
mfpenpri	WEP	World energy price	Elasticity
gdsm, R&D	GDS, R&D	Connectivity	Multiplier
govrevm	GOVREV	Government revenue multiplier	Multiplier
gdsm	GDS	Government spending by destination sector	Multiplier
gdsedm	GDS	Education spending distribution multiplier	Multiplier
govhhtrnpenm	GOVHHTRN	Government pension spending multiplier	Multiplier
firmtaxrm,	SAVINGS	National tax rates on firms, households, and indirect taxation	Multiplier
hhtaxrm (skilled, unskilled)	SAVINGS	National tax rates on households, broken down by skilled and unskilled	Multiplier
indirecttaxrm	SAVINGS	National tax rates on firms, households, and indirect taxation	Multiplier
ginidomr	GINIDOM	Domestic Gini Index	Growth Rate
ginidomm	GINIDOM	Domestic Gini Index multiplier	Multiplier
gdprext	GDP	GDP growth rate	Growth Rate
xshift	X, XS	Export shift as a result of trade promotion	Additive factor
protecm	M, MS	Protectionism in trade, multiplier on import prices	Multiplier
termtrm	TERMTR	Terms of trade balance, higher favors global south	Multiplier
xfdistockm	XFDISTOCK	Inward stocks of FDI multiplier	Multiplier
xfdistoutm	XFDISTOUT	Outward stocks FDI multiplier	Multiplier
xfdiwgrm	XFDI STOCK, XFDIOUT	World FDI growth rate multiplier	Multiplier
xportfoliom	XPORTFOLIO	Inward portfolio investment multiplier	Multiplier
xportstoutm	XPORTFOLIO	Outward portfolio investment stock multiplier	Multiplier
aiddon	AID	Aid foreign loan donations as % GDP	Additive factor
aidrecm	AID	Aid receipts as % GDP	Multiplier
aidlpm	AID	Aid foreign loan percentage multiplier	Multiplier
labinformshrm	LABINFORMSHR	Labor informal share multiplier	Multiplier
gdpnformshrm	GDPINFORMSHR	GDP informal share multiplier	Multiplier
govbusindxm	GOVBUSINDEX	Government business index multiplier	Multiplier
tefinfadjm	TEFF	Multiplier of impact of informal GDP share on productivity	Multiplier
taxinfadjm	HHTAXR, FIRMTAXR, SSWELTAXR	Multiplier of impact of informal GDP share on tax rates	Multiplier

randdexpm	RANDEXP	Total (public and private) expenditure on research and development multiplier	Multiplier
firmtaxrm	FIRMTAX	Tax rate on firm's multiplier	Multiplier
labinformcoeffbus	LABINFORMSHR	Informal labor share, coefficient of business index	Coefficient
labinformcoeffed	LABINFORMSHR	Informal labor share, coefficient of education years	Coefficient
labinformcoeffhhtrn	LABINFORMSHR	Informal labor share, coefficient of household transfers	Coefficient
labinformcoefftax	LABINFORMSHR	Informal labor share, coefficient of tax rate	Coefficient
gdpinformcoeffcorrupt	GDPINFORMSHR	Informal GDP share, coefficient of government corruption	Coefficient
gdpinformcoeffintercept	GDPINFORMSHR	Informal GDP share, intercept of model	Coefficient
gdpinformcoefflabinf	GDPINFORMSHR	Informal GDP share, coefficient of informal labor share	Coefficient
gdpinformcoeffrandd	GDPINFORMSHR	Informal GDP share, coefficient of R&D spending	Coefficient
gdpshadowcoeffintercept	GDPSHADOWSHR	Shadow economy GDP share, intercept of model	Coefficient
gdpshadowcoefflabinf	GDPSHADOWSHR	Shadow economy GDP share, coefficient of informal labor share	Coefficient
gdpshadowcoeffcorrupt	GDPSHADOWSHR	Shadow economy GDP share, coefficient of government corruption	Coefficient
gdpshadowcoeffrandd	GDPSHADOWSHR	Shadow economy GDP share, coefficient of R&D spending	Coefficient

Infrastructure

Parameter	Variable of Interest	Description	Type
infraroadm	INFRAROAD	Multiplier on road density expected/demanded	Multiplier
infraroadpavedpcntm	INFRAROADPAVEDPCNT	Multiplier on percentage of roads paved	Multiplier
Infraroadraitrgtval, Infraroadraitrgtyr	INFRAROADRAI	Target value/years after 2010 for achievement for population percentage living w/in 2km of an all-weather road	Absolute target
infraroadraisetar, infraroadraiseyrtar	INFRAROADRAI	Standard error target and years after 2010 for achievement for rural road access index	Relative target
infraelecgencapm	INFRAELECGENCAP	Multiplier on electricity generation capacity	Multiplier
infraelecaccm	INFRAELECACC	Multiplier on electricity access	Multiplier
enelecshrendemm	INFRAELECDEM	Multiplier on ratio of electricity use to total primary energy use	Multiplier
infraelectranlossm	INFRAELECTRANLOSS	Multiplier on the loss of electricity in transmission and distribution	Multiplier
ensolfuelm	ENSOLFUEL	Multiplier on the reliance on solid fuel as a source of energy	Multiplier

infraelecacctrgtval/ infraelecacctrgtyr	INFRAELECACC	Target value and years after 2010 for target achievement for population percentage w/ access to electricity	Absolute target
infraelecaccsetar/ infraelecaccseyrtar	INFRAELECACC	Standard error target and years after 2010 for population percentage w/ access to electricity	Relative target
ensolfueltrgtval/ ensolfueltrgtyr	ENSOLFUEL	Target value and years after 2010 for target achievement for percentage of households reliant on solid fuels	Absolute target
ensolfuelsetar/ ensolfuelseyrtar	ENSOLFUEL	Standard error target and years after 2010 for target achievement for percentage of households reliant on solid fuels	Relative target
watsafenewsw	N/A	Switch to activate 5-tier or 3-tier water model (0=3-tier model; 1=5-tier model)	Switch
sanithhmodel2sw	N/A	Switch to activate 5-tier or 3-tier sanitation model (0=3-tier model; 1=5-tier model)	Switch
landirareaequipm	LANDIRAREAEQUIP	Multiplier on land area equipped for irrigation	Multiplier
sanitationm	SANITATION	Multiplier on percentage of people with access to sanitation	Multiplier
watsafem	WATSAFE	Multiplier on percentage of people with access to safe water	Multiplier
watwastem	WATWASTE	Multiplier on percentage of people connected to wastewater collection system,	Multiplier
watwastetreatm	WATWASTETREAT	Multiplier on percentage of people connected to wastewater treatment	Multiplier
sanitationtrgtval/ sanitationtrgtyr	SANITATION	Target value and years after 2010 for target achievement for population percentage with improved access to improved sanitation, by category of	Relative target
watsafetrgtval/ watsafetrgtyr	WATSAFE	Target value and years after 2010 for target achievement for population percentage without access to improved sources of water	Relative target
sanitnoconsetar/ sanitimpconsetar/ sanithhconsetar/ sanitnoconseyrtar	SANITATION	Standard error targets and years after 2010 for target achievement for population percentage with varying access to sanitation	Relative target
sanithhm	SANITHH	Multiplier on percentage of people with access to sanitation by type	Multiplier
sanithhbasictrgtval sanithhbasictrgtyr	SANITHH	Target value and years from the base to reach at least basic sanitation services	Relative target
sanithhsafetrgtval sanithhsafetrgtyr	SANITHH	Target value and years from the base to reach safely managed sanitation services	Relative target
waterhhm	WATERHH	Multiplier on percentage of people with access to water by type	Multiplier
waterhhbasictrgtval waterhhbasictrgtyr	WATERHH	Target value and years from the base to reach at least basic water services	Relative target
waterhhsafetrgtval waterhhsafetrgtyr	WATERHH	Target value and years from the base to reach safely managed water services	Relative target

infratelem	INFRATELE	Multiplier on fixed-line telephone lines per 100 persons	Multiplier
ictbroadm	ICTBROAD	Multiplier on fixed-line broadband subscriptions per 100 persons	Multiplier
ictbroadmobilm	ICTBROADMOBIL	Multiplier on mobile broadband subscriptions per 100 persons	Multiplier
ictbroadtrgtval, ictbroadtrgtyr	ICTBROAD	Target value and years after 2010 for target achievement for number of subscriptions per 100 persons	Absolute target
ictbroadmobiltrgtval, ictbroadmobiltrgtyr	ICTBROADMOBIL	Target value and years after 2010 for target achievement for number of subscriptions per 100 persons; varies between 0 and 150	Absolute target
ictbroadmobilsetar, ictbroadmobilseyrtar	ICTBROADMOBIL	Standard error target and years after 2010 for target achievement for ICT mobile broadband access	Relative target
ictbroadsetar, ictbroadseyrtar	ICTBROAD	Standard error target and years after 2010 for target achievement for fixed broadband access	Relative target
ictmobilsetar, ictmobilseyrtar	ICTMOBIL	Standard error target and years after 2010 for target achievement for mobile phone access	Relative target
gdsm (infrastructure)	GDS	Gross domestic spending multiplier (infrastructure)	Multiplier
infrainvnewpubshrm	INFRAINVESTNEWPUB	Portion of maintenance funding coming from public sources	Multiplier
Infrainvmaintpubshrm	INFRAINVESTMAINTPUB	Portion of new infrastructure funding coming from public sources	Multiplier
hhsizem	GDS	Household size multiplier	Multiplier
infraroadpavedcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of paved roads	Multiplier
infraroadunpavedcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of unpaved roads	Multiplier
infraelecgencostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of electricity generation	Multiplier
infraelecaccruralcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of rural electricity access	Multiplier
infraeleaccurbancostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of urban electricity access	Multiplier
watsafecostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of safe water	Multiplier
watsafeimpcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of improved safe water sources	Multiplier
sanitationcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of basic sanitation	Multiplier
sanitationimpcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of improved sanitation	Multiplier
watwastetreatcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of waste water treatment	Multiplier
landircostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of equipping land for irrigation	Multiplier

Parameter		Description	Type
infratelecostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of telephone	Multiplier
ictmobilcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of mobile	Multiplier
ictbroadcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on unit cost of broadband	Multiplier
ictbroadmobilcostm	INFRAINVESTNEWPUB, INFRAINVESTMAINTPUB	Multiplier on mobile broadband	Multiplier

Agriculture

Parameter	Variable of Interest	Description	Type
clpcm	AGDEM	Caloric demand for agricultural production	Multiplier
clpccvm	CLPCCV, MALNPOPP	Multiplier on coefficient of variation for calories per capita	Multiplier
elascd	AGDEM	Elasticity of crop demand to changes in food price	Elasticity
elasmd	AGDEM	Elasticity of meat demand to changes in food price	Elasticity
elasfd	AGDEM	Elasticity of fish demand to changes in food price	Elasticity
indemm	INDEM	Industrial demand for crops	Multiplier
tgrld	AGP	Target growth rate in cultivated land	Initial
ylm	YL	Crop yield (agricultural production)	Multiplier
ylmax	YL	Maximum crop yield	Exogenous specification
envylchgadd	ENVYLDCHNG	Agricultural yield change	Additive factor
slr	AGP	Livestock slaughter rate	Exogenous specification
livhdpro	AGP	Livestock herd productivity gain with grain feeding	Exogenous specification
aquaculm	FISH	Fish production through aquaculture, multiplier	Multiplier
fishcatchm	FISH	Fish production through catch	Multiplier
aquaculgr	AQUACUL	Growth in the use of aquaculture	Growth Rate
aquaculconv	AQUACUL	The number years in which aquaculture growth rate converges to 0	Convergence rate
aglosstransm	LOSS	Agricultural wastage	Multiplier
aglossprodm	LOSS	Agricultural Production loss	Exogenous specification
aglossconsm	LOSS	Agricultural Consumption loss	Exogenous specification
aginvm	YL, IDS (agriculture)	Investment in agriculture	Multiplier
ldcropm	LD(crop land)	Share of crop land in total land	Multiplier
Elagind	AGP	Elasticity of industrial use of crops with price	Elasticity
elinag1	IDS (agriculture)	Elasticity of investment in agriculture to profit levels	Elasticity
elinag2	IDS (agriculture)	Elasticity of investment in agriculture to changes in profit level	Elasticity
malnelimstartyr	MALNPOP	Undernourishment elimination target start year	Standard error target start year

	MALNPOP	Undernourishment elimination target year	Standard error target year
malnelimtargetyr			
	MALNPOP	Undernourishment elimination	Switch
malelimprecisesw			

Energy

Parameter	Variable of Interest	Description	Type
endemm	ENDEM	Energy demand	Multiplier
elasde	ENP, WEP	Price elasticity of energy demand	Elasticity
carbtax	ENP	Carbon tax	Exogenous specification
enrgdpgr	ENP, QE	Growth in energy efficiency	Rate of change
enpm	ENP	Production multiplier	Multiplier
eprodr	ENP	Production growth rate	Growth rate
resorm	RESOR	Conventional resource multiplier	Multiplier
resorunconm	RESORUNCON	Unconventional resource multiplier	Multiplier
rdm	RESER	Discovery multiplier	Multiplier
etechadv	QE	Rate of technical advance in energy	Exogenous specification
etechadvuncon	QE	Rate of technical advance in unconventional energy	Exogenous specification
qem	QE	Capital output multiplier	Multiplier
eninvm	ENIV	Energy investment	Multiplier
enprix	ENPRI	Regional energy price	Exogenous specification
enml, enxl	ENM, ENX	Limits on energy imports and exports	Exogenous specification

Environment

Parameter	Variable of Interest	Description	Type
enpm	ENP	Energy production by type	Multiplicative
endemm	ENDEM, WEP	Energy demand multiplier	Multiplicative
carbtax	ENP, CARANN	Carbon tax	Exogenous Specification
qem	ENP	Capital-output ratio multiplier	Multiplicative
resorm	RESOR	Resource multiplier	Multiplicative
enrgdpgr	ENP	Energy efficiency	Growth rate
carfuel1	CARANN	Carbon generated by gas	Coefficient
carfuel2	CARANN	Carbon generated by natural gas	Coefficient
carfuel3	CARANN	Carbon generated by coal	Coefficient
envclimsens	CO2PPM, WTEMP	Time sensitivity of global temperature to carbon dioxide	Limit
carabr	CO2PPM, WTEMP	Carbon absorbed by oceans	Coefficient
carabrchng	CO2PPM, WTEMP	annual change in this absorption rate of carbon by oceans	Coefficient
envco2fert	AGP	Crop sensitivity to environmental change	Elasticity
envylchgadd	ENVYLDCHNG	Agricultural yield change	Additive factor

envylchgm	ENVYLDCHNG	Agricultural yield change	Multiplicative
forestm	WFOREST	World forest multiplier	Multiplicative
tgrld	WFOREST, LD	Land growth by type	Initial condition
carforst	CO2PPM	Level of carbon sequestered by forests	Coefficient
watres	Unknown	Renewable water resources	Exogenous specification
tgrld	AGP	Land growth by type	Initial condition
ylm	YL	Agricultural yield multiplier	Multiplier
envpm2pt5m	ENVPM2PT5	PM2.5 levels multiplier	Multiplier
ensolfuelm	ENSOLFUEL	Solid fuel use multiplier	Multiplier
ensolfuelsetar	ENSOLFUEL	Solid fuel use SE target	Standard error target
ensolfuelseyrtar	ENSOLFUEL	Solid fuel use SE target	Standard error target
ensolfueltrgtval	ENSOL FUEL	Solid fuel elimination target	Target
ensolfueltrgtyr	ENSOLFUEL	Solid fuel elimination target	Target
hlsolfuelsw	DEATHCAT	Relationship between solid fuel and respiratory diseases	Switch
climeconimpsw	CLIMECONIMP	Climate change to economy impact switch (1=on)	Switch
climeconimplin	CLIMECONIMP	Climate change to economy impact, linear term coefficient	Co-efficient
climeconimpsq	CLIMECONIMP	Climate change to economy impact, squared term coefficient	Co-efficient
climeconimpstk	VADD	Climate chnge to econ impact, portion affecting productivity or capital stocks	Multiplier
watdemandelas	WATDEM	Elasticity from water price to water demand	Elasticity
landirareaequipelas	LANDIRAREAACTUAL	Elasticity from water price to land equipped for irrigation	Elasticity
desali	WATERDESALINATED	desalination responsiveness to change in stock levels of price	PID factor
desald	WATERDESALINATED	desalination responsiveness to change in price	PID factor

Governance

Parameter	Variable of Interest	Description	Type
sfusehist	N/A	State failure switch to use history for base values(0=off; 1=on; 2=converge)	Switch
sfintlwaradd	SFINTLWAR	State failure/internal war addition	Additive
sfconv	SFINTLWAR	State failure convergence	Convergence speed (years)
sfmassrep	SFINTLWAR	Mass repression factor	Additive
wpextinterv	SFINTLWAR	External intervention factor	Additive
govriskm	GOVRISK	Government risk multiplier	Multiplicative
govriskweight	GOVRISK	Government risk weight	Weight
govrevm	GOVREV	Government Revenue Multiplier	Multiplier
firmtaxrm	GOVREV	Firm tax multiplier	Multiplier
hhtaxrm	GOVREV	Household tax rate multiplier	Multiplier

ssweltaxrm	GOVREV	Social Security multiplier	Multiplier
indirecttaxrm	GOVREV	Indirect tax multiplier	Multiplier
govcorruptm	GOVCORRUPT	Corruption Multiplier	Multiplier
govcorruptsetar	GOVCORRUPT	Corruption target	Standard error target
govcorruptseyrtar	GOVCORRUPT	Corruption target	Standard error target
goveffectm	GOVEFFECT	Effectiveness multiplier	Multiplier
goveffectsetar	GOVEFFECT	Effectiveness target	Standard error target
goveffectseyrtar	GOVEFFECT	Effectiveness target	Standard error target
govregqualm	REGQUALITY	Regulatory quality multiplier	Multiplier
govregqualsetar	REGQUALITY	Regulatory quality target	Standard error target
govregqualseyrtar	REGQUALITY	Regulatory quality target	Standard error target
econfreem	ECONFREE	Economic freedom multiplier	Multiplier
democm	DEMOCPOLITY	Democracy multiplier	Coefficient
swseffects	DEMOCPOLITY	Swing state effect	Additive factor
democimpus	DEMOCPOLITY	Democracy impetus by leading power	Coefficient
democimpoth	DEMOCPOLITY	Democracy impetus by other powers	Coefficient
DEMOCWDIR	N/A	Democracy wave direction (-1=down; 0=off; 1=up)	Switch
democwvlen	DEMOCPOLITY	Democracy wave length	Limit
democwvmax	DEMOCPOLITY	Democracy wave upper limit	Limit
democpolitysetar	DEMOCPOLITY	Democracy SE target	Standard error target
democpolityseyrtar	DEMOCPOLITY	Democracy SE year	Standard error target
freedomm	FREEDOM	Freedom multiplier	Multiplier
gemm	GEM	Gender empowerment multiplier	Multiplier
gemsetar	GEM	Gender empowerment target	Standard error target
gemseyrtar	GEM	Gender empowerment year target	Standard error target

International Politics

Parameter	Variable of Interest	Description	Type
cpowf	CPOW	Factor controlling military spending conversion	Convergence factor
cpowldcf	CPOW	Higher impact of military spending in LDCs	Convergence factor
drcpow	CPOW	Depreciation rate of conventional power	Rate of change
cpowdf	CIVDM	Conventional power, damage done by war	Coefficient
govnucwpadd	NPOW	Nuclear weapons stockpile change	Additive factor
wpwghtpow	POWER	Contribution of various components to power index	Index weight
wpgreatthresh	PCONGREAT	Systemic power share required for threshold of great power status	Coefficient
wpgreatlev	PCONGREAT	Systemic power share required for full great power status	Coefficient
wpconeusw	PCONGREAT	EU great power switch	Switch
wpconmax	PCONSYS	Maximum power concentration	Limit

wpconmin	PCONSYS	Minimum power concentration	Limit
wpgreat1	THREAT	Dyadic dispute probability, one great power	Coefficient
wpgreat2	THREAT	Dyadic dispute probability, two great powers	Coefficient
wppowtran1	THREAT	Power transition threshold	Coefficient
wppowtran2	THREAT	Increase in dispute probability with 10% greater power parity	Elasticity
wpcon	THREAT	Change in threat with power concentration	Coefficient
wpconsq	THREAT	Change in threat with power concentration	Coefficient
wpcontiguity	THREAT	Threat associated with geographic proximity	Elasticity
wpdemdist	THREAT	Response of threat to political distance	Elasticity
wpdemmin	THREAT	Response of threat to the minimum democracy level in the dyad	Limit
glocom	THREAT	Global community multiplier	Exogenous specification
wpcommun	THREAT	Response of threat to global community level	Elasticity
wptrade	THREAT	Change in threat with systemic trade	Elasticity
ally	THREAT	Alliance membership switch	Switch
wpally	THREAT	Reduction in threat with allied dyad	Elasticity
terdispute	THREAT	Territorial dispute or absence	Exogenous specification
wpterdisp	THREAT	Conflict arising from territorial disputes	Elasticity
wpthrconv	THREAT	Threat level convergence	Convergence Speed
wpthrwar	CWARPB	Portion of disputes that escalate to war	Coefficient
waron	CWAR, NWAR	War switch	Switch
cwarbase	CWARPB	Conventional war probability addition to base computation	Additive factor
cwarf	CWARPB	Conventional war forcing	Switch
cwarsv	CIVDM	Conventional war severity	Multiplier
nwarf	NWARPB	Probability that conventional war will escalate to nuclear	Coefficient
cdmf	CIVDM	Civilian war damage factor	Multiplier
nwarsv	CIVDM	Nuclear war severity	Multiplier
elndpow	CIVDM	Elasticity of nuclear damage with nuclear power	Elasticity
diploembassymaxm	DIPLOEMBASSYMAX	Maximum embassies abroad	Multiplier
diploigomaxm	DIPLOIGOMAX	Maximum international organization membership	Multiplier
diplotreatymaxm	DIPLOTREATYMAX	Maximum bilateral treaty participation	Multiplier