policy

December 2014

# MODELING THE DEMOGRAPHIC DIVIDEND

*Technical Guide to the DemDiv Model*

This publication was prepared by Scott Moreland, Elizabeth Leahy Madsen, Bernice Kuang, Matthew Hamilton, and Kaja Jurczynska of the Health Policy Project and Paul Brodish (consultant).

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Suggested citation: Moreland, S., E.L. Madsen, B. Kuang, M. Hamilton, K. Jurczynska and P. Brodish. 2014. *Modeling the Demographic Dividend: Technical Guide to the DemDiv Model.* Washington, DC: Futures Group, Health Policy Project.

ISBN: 978-1-59560-067-7

The Health Policy Project is a five-year cooperative agreement funded by the U.S. Agency for International Development under Agreement No. AID-OAA-A-10-00067, beginning September 30, 2010. It is implemented by Futures Group, in collaboration with CEDPA (part of Plan International USA), Futures Institute, Partners in Population and Development, Africa Regional Office (PPD ARO), Population Reference Bureau (PRB), RTI International, and the White Ribbon Alliance for Safe Motherhood (WRA).

# Modeling the Demographic Dividend: Technical Guide to the DemDiv Model

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# ACKNOWLEDGMENTS

The development of the DemDiv model benefited from the assistance and guidance of a number of people and institutions. First, the U.S. Agency for International Development (USAID) funded the research, design, validation, and initial applications of DemDiv through the Health Policy Project (HPP), and Linda Cahaelen's support was invaluable. Several demographers and economists offered useful suggestions during the model development process, including David Canning, Andrew Mason, Scott Radloff, Amy Tsui, and participants at a demographic dividend modeling seminar at the World Bank in July 2013.

Jason Bremner, Jessica Kali, and Colette Ajwan'g of the Population Reference Bureau offered excellent suggestions on the communication and dissemination of the model, and were instrumental in facilitating the pilot application in Kenya. The first applications of DemDiv in Kenya and Uganda, while not a focus of this report, contributed extensively to the refinement and finalization of the model. These applications were led by the National Council for Population and Development in Kenya and the National Planning Authority in Uganda. Additional guidance and direction were provided by Stephen Muchiri and Alice Wanjuu of the HPP team in Kenya, and Jotham Musinguzi and Eliya Zulu in Uganda.

Several Futures Group colleagues contributed significantly throughout the process, including Sarah Clark, Jay Gribble, Karen Hardee, Laura McPherson, Carol Miller, Elizabeth T. Robinson, Suneeta Sharma, Ellen Smith, Katie West-Slevin, and Erin Crandell.

# EXECUTIVE SUMMARY

In response to growing enthusiasm among policymakers for the potential economic benefits of the demographic dividend, the Health Policy Project developed a cross-national, customizable projection model, DemDiv. DemDiv is intended to be a user-friendly, evidence-based tool that can inform policymakers in high-fertility countries of the potential benefits of the demographic dividend and increase their support for investments in the multisectoral policies required to achieve those benefits. The model, which can be applied in any country, allows users to design multiple scenarios to show how the combined power of policy investments in family planning, education, and the economy can generate a demographic dividend not possible under the status quo. It is structured as a two-part model that projects demographic changes and economic changes with equations to estimate employment and investment, along with an estimation of gross domestic product (GDP) and GDP per capita.

This technical guide describes the rationale and design of the DemDiv model. It details and documents the demographic submodel and specific estimations of demographic equations for fertility, mortality, and life expectancy used in DemDiv. It also describes and documents the economic submodel, its application of the concept of total factor productivity, and the selection of macroeconomic policy variables. The guide concludes with a step-by-step, detailed users' manual explaining how to apply the DemDiv model. An appendix provides information on the definition and sources of all variables used in the model.

# ABBREVIATIONS

| | |
|---|---|
| Ca | abortion index |
| Cc | contraception index |
| Ci | insusceptibility index |
| Cm | marriage index |
| Cs | sterility index |
| CPR | contraceptive prevalence rate |
| DHS | Demographic and Health Survey |
| FLE | female life expectancy |
| FP | family planning |
| GCI | Global Competitiveness Index |
| GDP | gross domestic product |
| HDI | Human Development Index |
| HPP | Health Policy Project |
| ICT | information and communication technologies |
| IMR | infant mortality rate |
| PPI | postpartum insusceptibility |
| TF | total fecundity |
| TFP | total factor productivity |
| TFR | total fertility rate |
| U5MR | under-five mortality rate |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| USAID | U.S. Agency for International Development |

# INTRODUCTION

In many countries in sub-Saharan Africa, historically high fertility rates are starting to decline, presenting the growing potential for countries to benefit from an opportunity known as the demographic dividend. The dividend refers to faster economic growth that is caused in part by changes in population age structure. It can contribute to both national development and improved well-being for families and communities. Yet for the dividend to be achieved, countries must implement integrated programming to promote population change and invest in human capital and economic development.

There has been increasing interest in the economic benefits of attaining the demographic dividend in sub-Saharan Africa. The Ministerial Statement published during the 2013 meeting of African Union Ministers of Finance included a section noting, “the importance for Africa to introduce immediate measures to capitalize on its demographic dividend, through increased and sustained investments in health and education, particularly for women, the girl-child, the youth and disadvantaged social groups” (United Nations and African Union, 2013). With its clear ties to economic growth, the dividend has consolidated interest in population issues among policymakers whose priorities lie outside the health realm. This has built support for integrated, multisectoral development interventions ranging from family planning (FP) to job creation for young people.

Meanwhile, the 2012 London Family Planning Summit created renewed momentum for family planning, as donors and developing countries committed billions of dollars to support 120 million new contraceptive users by 2020. To ensure that these new Family Planning 2020 (FP2020) commitments are fully country-owned and viewed as national priorities, supporters must strengthen engagement with policymakers beyond the health sector and establish clear linkages between FP investments and overarching development goals. The demographic dividend is a clear opportunity to demonstrate how population changes motivated by FP policies and programs amplify the impact of other necessary development initiatives in employment, education, health, and the macroeconomic environment.

However, the demographic dividend is a complex concept. The changes in age structure, as well as the range of policy investments required for it to be successfully achieved, are not widely understood. Policymakers often assume that the dividend’s economic benefits will accrue automatically. Instead, context-specific investments in family planning, education, and the economy are required. This technical guide describes the rationale and design of the DemDiv model, an effort by HPP to meet growing enthusiasm for the topic with a deeper understanding that can promote tailored and effective policy investments. We believe this to be the first cross-national, customizable projection model available within the public domain that allows users to quantify the demographic dividend in individual countries and demonstrate the associated social and economic benefits of demographic changes.

## Approach and Objectives of the DemDiv Model

DemDiv addresses the complexity of the demographic dividend by linking age structure with social and economic development, enabling policymakers to quantify the changes that would be required to successfully achieve a demographic dividend. It does so by allowing the user to design multiple scenarios to show how the combined power of multisectoral policy investments can generate a demographic dividend not possible under the status quo.

Given its target audience, the model is designed to be empirically sound and offer broad utility in policy decision making. The objectives for creating the DemDiv model are twofold. First, to meet gaps in existing research by developing, testing, and offering a clear, evidence-based tool for in-country use that can inform policymakers in high-fertility countries of the potential benefits of the demographic dividend.

Second, to generate policymakers' support for investments in the multisectoral policies required to achieve those benefits.

In order to accurately describe and project the demographic dividend, the model is not limited to either population or economic inputs, but addresses the interplay between them, as affected by other social and development variables. In addition to being comprehensive in scope, the model is based on a foundation of empirical and statistical research.

The model is both adaptable and accessible to a range of users in countries around the world. DemDiv is like other models developed by Futures Group, HPP, and its predecessors, in that diverse audiences from various sectors can be trained to use it in as little as one day, and it requires no proprietary software or advanced statistical knowledge. The model allows for comparisons of several different scenarios to show the varying benefits of different combinations of investments. Although the model contains default data from international sources, it is also customizable, allowing users to enter context-specific data and set all future policy goals. These features allow the model to be fully owned by its users and sustained for repeated application or updates over time.

## Overview of the Model's Structure

Conceptually, the model's structure is not new. It follows, to a large extent, in the tradition of simulation modeling employed by Coale and Hoover (1958) and, more recently, Ashraf et al. (2013). In developing DemDiv, we also drew on an existing econometric model to forecast the demographic dividend by Bloom et al. (2010), which was presented with results from Nigeria. Its authors developed a cross-national regression to project change in GDP per capita based on age structure, trade openness, institutional quality, life expectancy, and geographic location.

We aimed to build upon previous models in ways that would be relevant to DemDiv's target audience of policymakers outside the health sector in high-fertility countries. Like others, we used a statistical approach, including multiple linear regression, but further developed a two-part model describing demographic and economic changes with equations to estimate employment, investment, and GDP. The demographic component underlies the model structure, projecting child mortality, dependency ratio, fertility, population size and structure, and life expectancy. These demographic calculations then feed into the economic model, which consists of three equations describing capital formation, employment growth, and total factor productivity as a function of age structure and other social and economic variables. The two model components interact over the projection period to describe the combined effects of changes in both submodels, ultimately projecting GDP and GDP per capita.

When applied to a specific country, users may input different scenarios based on their specific goals for the policy variables. Users can choose to design multiple scenarios to see the effects of different policies by manipulating the following variables:

- Contraceptive prevalence rate (CPR)
- Postpartum insusceptibility
- Sterility
- Education
- Public institutional quality
- Labor market flexibility
- Financial market efficiency
- Imports
- Information and communication technologies (ICT) infrastructure

The main economic and demographic outputs of the model are

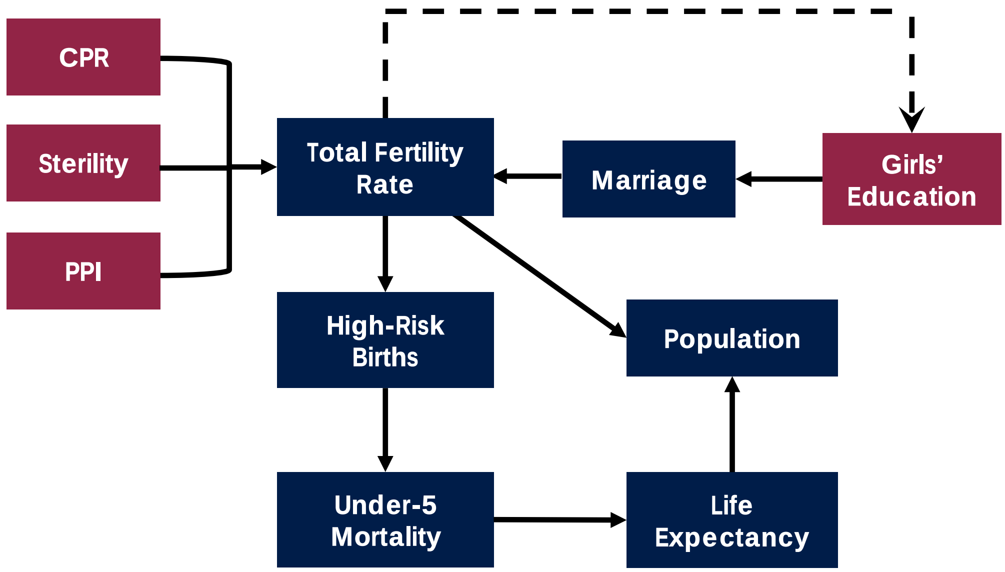
| Economic | Demographic |
| --- | --- |
| Labor force by age and sex | Population by age and sex |
| Employment | Dependency ratio |
| Investment (new capital formation) | Fertility rate |
| GDP | Life expectancy at birth |
| GDP per capita | Infant, child and maternal mortality |
| GDP growth rate | |

# DEMOGRAPHIC MODEL

The demographic submodel (Figure 1) within DemDiv projects the determinants of fertility and mortality and, thereby, population growth and age structure. These are subsequently incorporated into the economic model. In Figure 1, the red boxes represent the model's user inputs, which are variables that can be influenced by program and policy changes:

1. Girls' education (school life expectancy)
2. Contraceptive prevalence rate
3. Postpartum insusceptibility (PPI)
4. Sterility

**Figure 1: Demographic Model**




Policy variables that may not be directly related to fertility can indirectly affect changes in demographic and health variables. For example, female education is consistently linked to delayed childbearing (Ainsworth et al., 1996; Singh and Samara, 1996; Lloyd and Mensch, 2006), especially at post-primary levels, including through delayed age at marriage and increased use of family planning. In this way, increased female education leads to fewer births and lower fertility, indirectly impacting population dynamics (Martin and Juarez, 1995; Jain, 1981). In DemDiv, the user can adjust the values of these inputs as policy variables to estimate the demographic impact of education or family planning-related programs and policies. The size and direction of the impact of each variable is estimated using data from several different multi-country data sets, each containing data from between 44 to 196 countries and territories from the years 2000 to 2011.

## Demographic Estimation Methodology

The demographic submodel was based on a previous Futures Group model, RAPID*Women* (Moreland, 2012), but all underlying demographic equations were re-estimated for DemDiv. All of the statistical relationships were determined using a simple linear regression in Stata 12. In some cases, the data were log transformed before regression (e.g., the natural log of the dependent variable was regressed against the natural log of the independent variable for improved fit). For the log-transformed equations, the resulting coefficients can be interpreted as "elasticities," or the percentage change in the dependent variable that is associated with a one percent change in the independent variable. A complete list of data sources is provided in Appendix A.

### Total Fertility Rate

The total fertility rate (TFR) is at the heart of the demographic model and is used to calculate the number of annual births, which informs population growth and age structure. DemDiv uses the Bongaarts (1978, 1984) proximate determinants model to project TFR. As depicted in Figure 1, TFR is directly affected by three variables entered by the user and indirectly affected by girls' education, by way of marriage.

The Bongaarts framework is repeated here in full:

$$TFR_t = Cm_t \bullet Ci_t \bullet Ca_t \bullet Cs_t \bullet Cc_t \bullet TF$$

The index of marriage (**Cm**) is simply the percentage of women of reproductive age who are married or in union. The baseline value is input from the Demographic and Health Survey (DHS), and future values are calculated by the model, based on user-entered education inputs as described below.

The insusceptibility index (**Ci**) is calculated as the ratio of the average birth interval in months, with and without breastfeeding:

$$Ci = 20.0 / (18.5 + \textit{Period of postpartum insusceptibility in months})$$

Ci is an exogenous variable that reflects the duration of a woman's postpartum amenorrhea (temporary infecundability or inability to conceive) due to breastfeeding and, in this model, postpartum abstinence, which combined create insusceptibility to conception. The baseline value is input and future values are projected by the user, who can choose whether or not to vary from the baseline value.

DemDiv omits the index of induced abortion (**Ca**).The model does not vary the level of this index, and calculations were adjusted accordingly.

The index of sterility (**Cs**) is normally calculated from the percentage of women in union who remain childless at the end of their reproductive years. As with PPI, the baseline value is input from the DHS, and future values are projected by the user who can choose whether or not to vary from the baseline value. Assuming that the percentage of married/in-union women who complete their reproductive years without giving birth are sterile, Cs is calculated as:

$$Cs = (7.63 - 0.11 * \textit{Percent sterile})/7.3$$

The index for contraception (**Cc**) is calculated as a function of the CPR and method mix, which can be adjusted between modern and traditional methods by the user. CPR is interpolated in a linear fashion over time to reach user-input future values. The index is calculated from the prevalence and effectiveness of modern and traditional methods as:

$$Cc = 1\text{-}1.08\ (prev_m * effectiveness_m) + (prev_t * effectiveness_t)$$

**TF** is an index of total fecundity and is the number of children a women would have if all the other proximate determinants were at their minimum levels. This variable is not likely to change and is not a policy variable. As with the abortion rate, TF is not used as an input. The model solves for TF based on its calculations of the other proximate determinants.

The model retains Cc, Cs, Ci, and Cm. Cc, Cs, and Ci are exogenous and user-controlled. Cm is endogenous and calculated by the model as described below as a function of girls' education.

### *Percentage of Women Married or in Union*

The percentage of women who are married or in union, described above as Cm, is an important proximate determinant of fertility because it reflects the proportion of women who are presumably sexually active on a regular basis (Bongaarts, 1978). In DemDiv, this variable is modeled as a function of female education. Increased educational attainment can lead to delays in the age of marriage as women and girls stay in school longer (Aryal, 2007; Islam and Ahmed, 1998). Also, increased educational attainment may contribute to other life choices for girls and women, and more educated women are also more likely to enter into formal work (Klasen, 2002). In this way, female education indirectly impacts fertility, and thus population dynamics.

The relationship between the expected number of years in school, referred to by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as school life expectancy, and the percentage of women in union was estimated using the most recent data from UNESCO and DHS. The DHS data spanned 2000–2011, whereas UNESCO data spanned 2010–2012. On average, the span of years between the most recent DHS report and the most recent available UNESCO data was approximately four years. The data were log transformed for easier interpretation as elasticities. The coefficient for female school life expectancy indicates that gains in female education have a statistically significant negative relationship with the proportion of women married or in union (Table 1).

**Table 1: Estimated Equation for Percentage of Women Married**

| Ln (Percentage of Women Married) | Coefficient | t statistic | R-squared | n |
|---|---|---|---|---|
| Ln (Female School Life Expectancy) | -0.332 | -4.38 | 0.314 | 44 |

### *Female Education*

In addition to using female education to influence fertility via the percentage of women married, the model includes a feedback loop addressing the effect of fertility on female education. As described above, it is well-established that lower levels of fertility lead to higher levels of female education. Within the same generation, this is because children are time-intensive to care for and women who delay childbearing while in school can extend their educations. For the model, we regressed the mean years of female education, which measures the average educational attainment among adult women ages 25 and older against the TFR and obtained the results shown in Table 2. As expected, increases in TFR are significantly associated with a negative effect on female educational attainment.

**Table 2: Estimated Equation for Female Education**

| Ln (Mean Years of Female Education) | Coefficient | t statistic | R-squared | n |
|---|---|---|---|---|
| Ln (TFR) | -0.795 | -13.78 | 0.570 | 145 |

### *High-risk Births and Under-five and Infant Mortality*

Mortality at early ages influences population growth and age structure. Changes in mortality at the earliest ages have an especially important impact on demographic processes because they are applied when the cohort is at its largest. Changes in fertility can lead to improvements in infant and child mortality in two different ways. First, a decrease in fertility which results in a lower absolute number of births will decrease the absolute number of infants and children at risk of death, although perhaps not the infant and child mortality rates. Second, a decrease in fertility can lower the percentage of births termed “high risk.”

The DHS defines births as high risk if they have any of the following inclusion criteria:

- Mother is under age 18 (too young)
- Mother is over age 34 (too old)
- Birth is less than 24 months after previous birth (too close)
- Birth is to a mother who has had more than three births (too many)

To analyze these linkages, the authors examined DHS data for countries with surveys from 2000 to 2011. First, the project regressed the percentage of high-risk births against TFR. The result was a large, statistically significant positive relationship, indicating that higher fertility is associated with a higher percentage of high-risk births among all births.

*TFR → Percent of births at risk*

This is because as fertility falls, high-parity births must also decline. Furthermore, declines in fertility are often observed when women delay childbearing or end their reproductive careers earlier; thus reducing the high-risk births that occur at the extremes of a woman's reproductive lifespan. Births spaced too closely are also more likely to occur where fertility is high.

Following examples from RAPID*Women* and Ross and Stover's analysis (2005), we further examined the downstream impact of decreased fertility on mortality.

*TFR → Percent of births at risk → Infant mortality rate (IMR)*
*TFR → Percent of births at risk → Under-five mortality rate (U5MR)*

Using data from DHS, we regressed the infant mortality rate against the percentage of births with any risk, as well as the under-five mortality rate against the percentage of births with any risk. Both regressions produced a significant positive relationship. This indicates that an increase in the proportion of births that are high risk is associated with increased infant and child mortality.

The results of the statistical analysis established the relationships that are used to link fertility to mortality (Table 3). Although we calculated equations for both infant and child mortality, only child mortality is used in the demographic submodel, where it affects female life expectancy, as described below.

**Table 3: Estimated Equations for Any Risk, Infant Mortality, and Under-five Mortality**

| Any Risk | Coefficient | t-statistic | R -squared | n |
|---|---|---|---|---|
| TFR | 7.28 | 16.0 | 0.740 | 92 |
| Infant Mortality Rate | | | | |
| Any Risk | 1.49 | 8.79 | 0.462 | 92 |
| Under-five Mortality Rate | | | | |
| Any Risk | 3.13 | 10.02 | 0.527 | 92 |

### *Female Life Expectancy*

Life expectancy is a high-level health indicator that synthesizes mortality at all ages at one point in time. Reduced mortality, or improved survival at various ages will increase life expectancy and impact population projections. Developing countries generally experience substantial increases in life expectancy as infant and child survival rates improve with the introduction of vaccines, better nutrition, and control of infectious disease. Furthermore, changes in fertility will also affect the proportion of births which are high risk, further impacting infant and child mortality.

To estimate the statistical relationship between female life expectancy (FLE) and the under-five mortality rate, we used cross-sectional log-transformed data from the United Nations (2013) for all countries in the world. The results were statistically significant and demonstrated that overall, as under-five mortality decreases, FLE increases. Additionally, a closer inspection of the data showed that this relationship is stronger when countries had particularly high under-five mortality rates.

Specifically, when the under-five mortality rate is above approximately 50 per 1,000 births, the slope between FLE and U5MR is steeper, indicating that a change in mortality would be associated with a larger change in FLE than at lower mortality rates. To address this observation, the model was fit with a linear spline at around 50 under-five deaths per 1,000 births to account for the stronger relationship observed at higher mortality. Five Southern African countries (Botswana, Lesotho, South Africa, Swaziland, and Zimbabwe) had residuals greater than three, a standard cutoff point, such that their FLE values were much lower than anticipated based on their child mortality values. These countries likely exhibit unexpectedly low FLE due to the high prevalence of HIV and thus were excluded from the final analysis. Exclusion of these extreme values improved the $R^2$ value (i.e., how well the data fit to the model) and the Akaike Information Criterion (i.e., the relative quality of the model) but did not appreciably influence the magnitude of the coefficients (Table 4).

**Table 4: Estimated Equation for Female Life Expectancy at Birth**

| Ln (Female Life Expectancy) | Coefficient | t-statistic | R-squared | n |
|---|---|---|---|---|
| Ln (Under-five Mortality Rate) when U5MR < 50.9 | -.059 | -18.3 | 0.950 | 196 |
| Ln (Under-five Mortality Rate) when U5MR > 50.9 | -.287 | -22.5 | 0.950 | 196 |

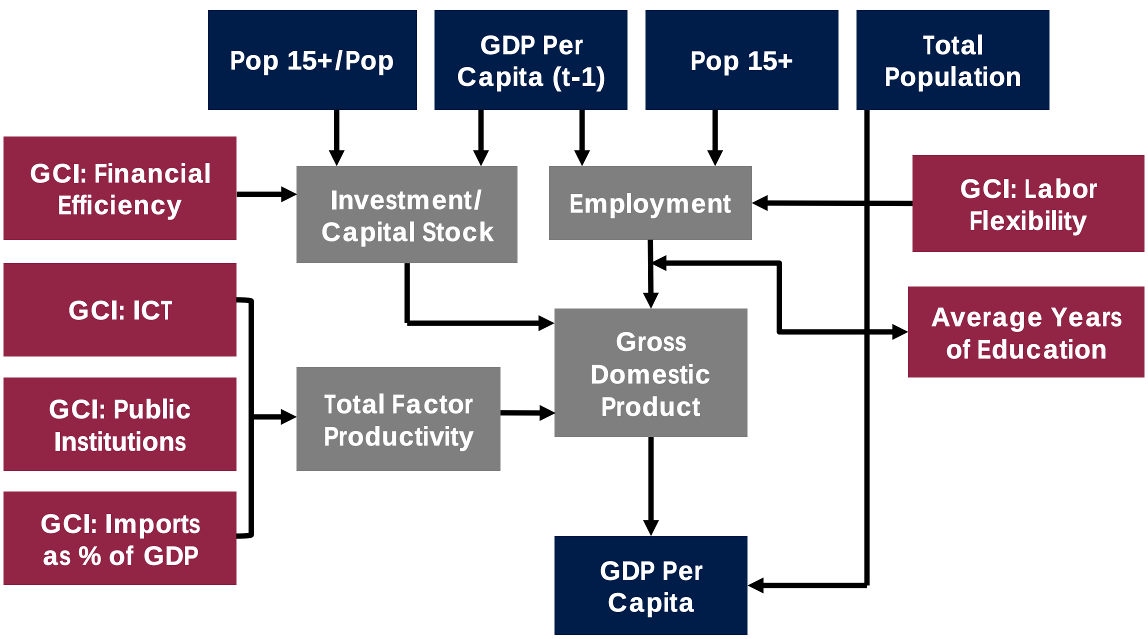
# ECONOMIC MODEL

The economic model integrates results from the demographic model and several new policy variables to project GDP and GDP per capita. The GDP projection, as described in detail below, is based on three components: investment, employment, and total factor productivity (TFP), a measure of how efficiently economic inputs are being used. As depicted in Figure 2, the investment and employment equations each integrate results from the demographic model, which projects the size of the working-age population, with economic policy variables shown in red boxes. The TFP equation is based solely on economic policy variables. The results of the employment equation are then combined with an education parameter that is partially set by the user to project the efficiency of the labor force and ultimately, together with the investment and productivity results, used to project GDP.

As with the demographic model, the red boxes in Figure 2 represent user inputs, which are variables that can be influenced by programs and policy change.

1. Financial market efficiency
2. ICT infrastructure
3. Public institutions
4. Imports
5. Labor market flexibility
6. Education

**Figure 2: Economic Model**




### *Projecting GDP*

In developing the model, the authors estimated an equation to project GDP based on recent data from 96 countries for capital (Berlemann and Wesselhöft, 2012) and employment (International Labor Organization, 2013). As a first step to construct the model, a Cobb-Douglas (Cobb and Douglas, 1928) production function was used to estimate the relationship among GDP, capital, and labor:

$$Y_i = \bar{A}_i {K_i}^{\alpha} {H_i}^{1-\alpha}$$

As is common in the literature (Hall and Jones, 1999), we assume α = 1/3 and constant returns to scale. Y is GDP, K is capital, and H is the human-capital augmented labor (employment) factor input. (Although exogenous in the core model, when DemDiv is applied by the user to make projections, these factors become endogenous). Since α is fixed, we estimated the productivity parameter $\bar{A}$, also called the total factor productivity.

We then estimated equations to help predict and project the three components of GDP: capital, employment, and TFP. The following sections describe the approach in detail.

### *Total Factor Productivity*

Recent macroeconomic literature points to the importance of TFP as a determinant of cross-country per capita income differentials and suggests that TFP differentials are persistent and large (Kumar and Chen, 2013). TFP is based on the theory that differences among countries in the levels of capital and labor are not sufficient to explain differences in output per worker. Prescott (1998) for example, concludes that TFP must be studied to understand inter-country differences. The TFP approach has also been used by Hall and Jones (1999), Klenow and Rodríguez-Clare (1997), Kogel (2005), and Hendricks (2002).

To include TFP as a variable in the model, we needed estimates for each country. While there are no data available for TFP ( $\bar{A}_i$ ) we calculated it by solving the definition of Y in the production function for A, since we know Y, K, and H for each country:

$$Y_i = \bar{A}_i K_i{}^{\alpha} H_i{}^{1-\alpha}$$

$$\frac{Y}{H} = \frac{AK\hat{}\alpha}{H\hat{}\alpha}$$

Defining *y* = Y/H and *k* = K/H it then follows that:

$$A = \frac{y}{k\hat{}\alpha}$$

Hall and Jones (1999) and Klenow and Rodríguez-Clare (1997) calculate human capital based on returns to schooling estimated in Mincerian wage regressions (Mincer, 1974). In particular, Hall and Jones (1999) calculate human capital-augmented labor from the following equation with $L_i$ denoting homogenous labor (which in DemDiv is employment), $\varphi(E_i)$ representing the efficiency of a unit of labor given $E_i$ years of schooling, and the derivative $\varphi'(E_i)$ representing the Mincerian return to schooling:

$$H_i = e^{\phi(E_i)} L_i$$

Hall and Jones (1999) calculate $H_i$ by measuring $E_i$ with the average years of school attainment of the population of 25 years and older. They assume $\varphi(E_i)$ to be piecewise linear. Furthermore, they base their Mincerian returns on a survey of Mincerian returns for countries in the world economy by Psacharopoulos (1994). For the first four years of $E_i$, Hall and Jones (1999) assume a Mincerian return of 13.4 percent and for the next four years, a value of 10.1 percent. For any year beyond the eighth year, they assume a value of 6.8 percent. We adapted this approach and approximated the step function for returns to education with a continuous linear equation:

$$\varphi(E) = 0.14 - 0.006 * E \text{ for } E > 0$$

In DemDiv, the education variable used in the TFP calculation is mean years of educational attainment among the adult population (Barro and Lee, 2013). Although the user establishes target values for this indicator in the policy scenarios, the ultimate value projected by the model may fluctuate somewhat based on the TFP equation. Given this, the user may choose to adjust the target value for mean years of education entered in the policy scenarios to take this fluctuation into account.

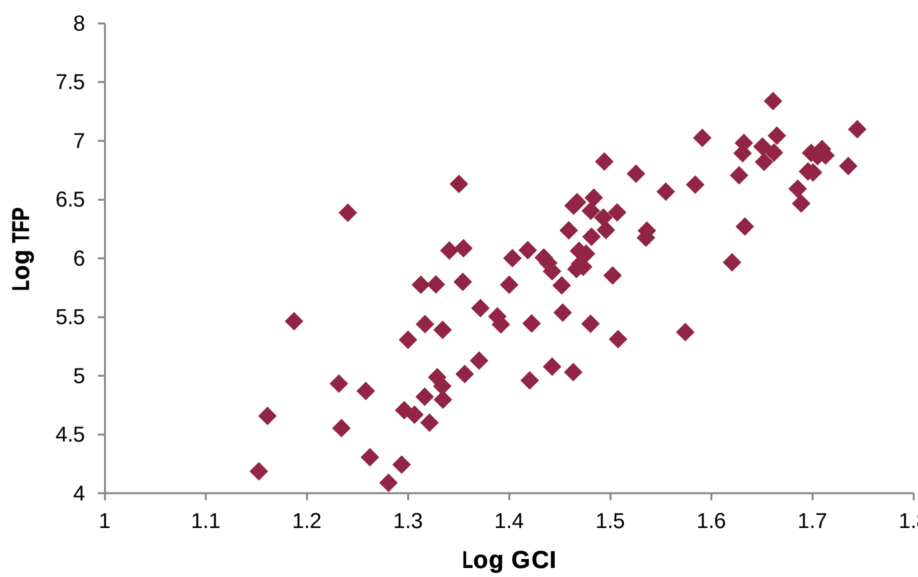
Explaining why TFP differs across countries is an important focus of macroeconomic research. Several reasons for differences in TFP have been identified in previous research. Kumar and Chen (2013), who modeled changes in TFP, found that TFP grows faster in countries where it is already high. In addition, higher levels of health, education, and urbanization are associated with higher TFP growth. In contrast, trade openness is associated with lower TFP growth. Bils and Klenow (2000) found that property rights, trade openness, and education were important factors in TFP variation. Kaufmann et al. (2000) pointed to governance factors such as voice and accountability, political stability, government effectiveness, regulatory quality, and corruption. Easterly and Levine (2002) further emphasize TFP as a major factor in explaining economic growth over factor endowments and argue that policy matters. Minoiu and Pikoulakas (2008) explored the influence of social infrastructure as measured by an economic security index. Hall and Jones (1999) also emphasized the importance of institutions, government policies, and social infrastructure.

### *The Global Competitiveness Index*

Drawing on these TFP-related factors, the authors used data from *The Global Competitiveness Report,* published annually by the World Economic Forum (Schwab, 2012). The report measures the relative competitiveness of the world's economies through its Global Competitive Index (GCI). This index is computed from a comprehensive database of more than 100 indicators measuring the microeconomic and macroeconomic foundations of national competitiveness, defined as "*the set of institutions, policies, and factors that determine the level of productivity of a country*" (Schwab 2012, p. 4, emphasis original). This in turn determines both the level of prosperity that can be earned by an economy (e.g., GDP per capita) and the rates of return obtained by investing in it that drive growth (e.g., rate of growth in GDP per capita). Thus the index captures both static and dynamic components of national economic competitiveness.

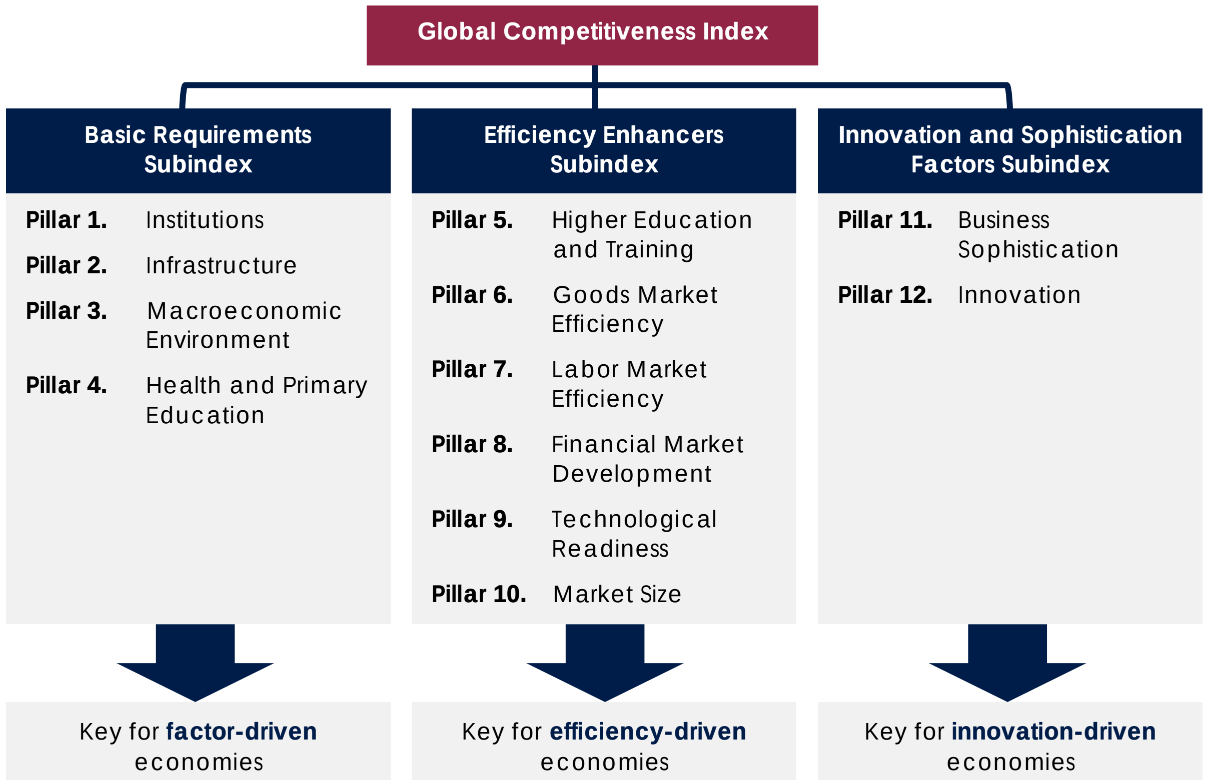
We examined the relationship between TFP as calculated above and the overall GCI score. As shown in Figure 3 (using a log scale), there is a strong relationship between overall GCI and TFP.

**Figure 3: Relationship between the GCI and TFP**




The GCI aggregates more than 100 indicators arranged in 12 "pillars" of competitiveness. These pillars and their components were constructed based on a range of factors reported in the literature to be predictive of economic productivity. These factors include investments in physical capital and infrastructure, human capital (e.g., education and training), technological progress, macroeconomic stability, good governance, firm sophistication, and market efficiency; all of which can operate simultaneously (Sala-i-Martín et al., 2004). These pillars are grouped into three domains (Figure 4).

**Figure 4: The Global Competitiveness Index Framework**




Source: Schwab 2012.

While all pillars are important in all countries, their relative importance varies by the country's stage of development. The GCI report distinguishes among three sets of indicators: basic requirements, efficiency enhancers, and innovation and sophistication factors. In computing the GCI, basic requirements are more heavily weighted among stage one, factor-driven economies (generally those with GDP per capita less than US$2,000) and are weighted less heavily among the most-developed nations (generally those with GDP per capita greater than US$17,000). Similarly, efficiency enhancers are more important among efficiency-driven economies in the midrange of GDP per capita Innovation and sophistication factors are most relevant among the most developed nations. The theory behind these pillars, which can be considered determinants of productivity, is strong. For example, the quality of public institutions has a significant effect on competitiveness and growth (Easterly and Levine, 1997). It affects the organization of production, investment decisions, and the distribution of the costs and benefits of development strategies and policies (Schwab, 2012).

For the purpose of predicting TFP, selected indicators from the GCI pillars were incorporated based on determinants of TFP previously suggested in the literature. Specifically, we conceptualized TFP as being determined by factors around the GCI pillars of Institutions (Pillar 1), Goods market efficiency (Pillar 6), and Technological readiness (Pillar 9). Within the Global Competitive Index each of these pillars contains a series of subpillars and indicators.

Within the pillar of Institutions (Pillar 1), the GCI framework includes subpillars of public and private institutions. We focused on the public institutions subpillar (1A) as a TFP-predicting variable, in part because it addresses issues policymakers can affect: property rights (including intellectual property), division of powers, corruption, regulatory burdens, transparency, waste in government spending, and public safety. Economies where these factors are not sufficiently addressed lose significant productivity to irregular payments, protection costs, and bureaucracy.

For the next variable to determine TFP, we focused on trade openness. Specifically, the project chose the indicator imports as a percentage of GDP (GCI indicator 6.14) under the pillar of Goods Market Efficiency (Pillar 6). For the main purposes of the Global Competitive Index, higher values of market competitiveness reflect a greater openness of the economy; and thus receive a higher ranking in the calculation of the overall GCI. However, from the standpoint of predicting TFP, we argue that higher values of this indicator (i.e., a greater dependence on imports relative to exports), will be associated with lower values of TFP and among other things, GDP.)

As a third variable to predict TFP, we selected GCI subpillar 9B, information and communication technologies use, under the pillar of Technological Readiness (Pillar 9). This subpillar includes indicators on internet use, connectivity, bandwidth, and on mobile phone subscriptions. It directly affects overall efficiency of communication, as well as the breadth and quality of information available to producers and consumers, and therefore their productivity.

Additional GCI variables, specifically the subpillars of financial market efficiency and labor market flexibility, were included in the model's investment and employment equations respectively, as described below.

Multivariate linear regression of log-transformed data was used to calculate estimates of the contributions of the GCI economic and governance policy variables to TFP. The results for the TFP equation estimations are shown in Table 5.

**Table 5: Total Factor Productivity (TFP)**

| Ln (TFP) | Coefficient | t statistic | R-squared | n |
|---|---|---|---|---|
| Ln(GCI 1A: Public Institutions) | 0.623 | 3.10 | 0.84 | 88 |
| Ln(GCI 9B: ICT Use) | 1.187 | 14.07 | | |
| Ln(GCI 6.14: Imports as % of GDP) | -0.219 | -3.28 | | |

Each of the three GCI variables used to predict TFP (GCI 1A, GCI 9B, and GCI 6.14) are significant with the expected positive and negative signs. ICT use has the largest effect size and the lowest uncertainty level. Public institutions are also significantly and positively related to TFP. The imports variable is negatively related to TFP and is significant, but has a small coefficient.

Calculated values of TFP are used to project GDP according to the Cobb-Douglas (1928) production function described above, which also integrates employment and education. These results are then integrated with those from the demographic submodel to produce the primary output variable of DemDiv, which is GDP per capita.

### *Employment and Investment Methodology and Results*

In addition to TFP, the GDP production function requires projections of capital and labor/employment. We therefore estimated corresponding equations. One equation estimated investment per working-age adult and the other estimated the rate of growth of employment:

$$\log(I/\mathrm{WA}) = \beta_0 + \beta_1\log(Y/WA) + \beta_2\log(WA/Pop) + \beta_3\log(GCI8A\_Efficiency)$$

$$\log(\Delta E/E) = \beta_0 + \beta_1\log(\Delta WA/WA) + \beta_2\log(\Delta Y/Y) + \beta_3\log(GCI7A\_Flexibility)$$

Where:

*GCI8A_Efficiency* = Financial market efficiency, GCI subpillar 8A

*GCI7A_Flexibility* = Labor market flexibility, GCI subpillar 7A

Table 6 shows the regression results for investment. All of the independent variables are positive and significant. The first is GDP relative to the working-age population, which is defined as the population ages 15 years and older. Wealthier countries are likely to have higher levels of investment.

Next, we hypothesized that as the age structure changes in favor of relatively more working-age adults, savings rates, and therefore investment rates, will increase. This means that increases in the age structure variable, the ratio of the population over age 15 to the total population, will have a positive impact on investment, which is supported by the regression. Inclusion of an age structure variable in the investment equation is a key element of the demographic dividend approach.

The authors also included the GCI variable on financial market efficiency (GCI subpillar 8A), which is also positive and significant. This subpillar is an index of factors relating to access to financial services, loans, and venture capital. Regardless of other factors, individuals and businesses are unlikely to invest in an economy unless they can do so easily and without excessive costs.

**Table 6: Investment per Working-age Adult**

| Ln (Investment/Working-Age) | Coefficient | t statistic | R-squared | n |
|---|---|---|---|---|
| Ln(GDP/Working-age) | 0.875 | 30.63 | 0.97 | 126 |
| Ln(Working-age/Population) | 0.77 | 2.73 | | |
| Ln(GCI 8A: Financial Market Efficiency) | 0.352 | 2.52 | | |

For the employment equation, we modeled the growth rate of employment as a function of the growth rates on GDP and of the working-age population (ages 15 years and older). Both variables were expected to have positive effects on employment growth. As an economy grows faster, its demand for labor would increase, wages would increase, and therefore more workers would join the labor force and be employed. As the working-age population increases, one expects a loosening of the labor market, falling wages, and an uptake in employment as firms move down their labor demand curves. We considered the rate of change in the labor force as an alternative to the rate of change in the working-age population. Data on labor force participation rates are problematic, however, and the estimations were not significant.

Table 7 shows the results of our statistical estimation. Both the working-age and income growth rate variables are significant and have the expected positive relationships. We also included labor market flexibility (GCI subpillar 7A) as a policy variable, and it was positive and significant. This subpillar is an index formed from indices of cooperation in labor-employer relations, flexibility of wage determination, hiring and firing practices, redundancy costs, and the extent and effect of taxation, each of which is likely to affect employment growth.

**Table 7: Employment Growth**

| Ln (ΔE/E) | Coefficient | t statistic | R-squared | n |
|---|---|---|---|---|
| Ln(ΔWA/WA) | 0.682 | 8.63 | 0.64 | 117 |
| Ln(ΔGDP/GDP) | 0.483 | 4.91 | | |
| Ln(GCI 7A: Labor Market Flexibility) | 0.593 | 1.75 | | |

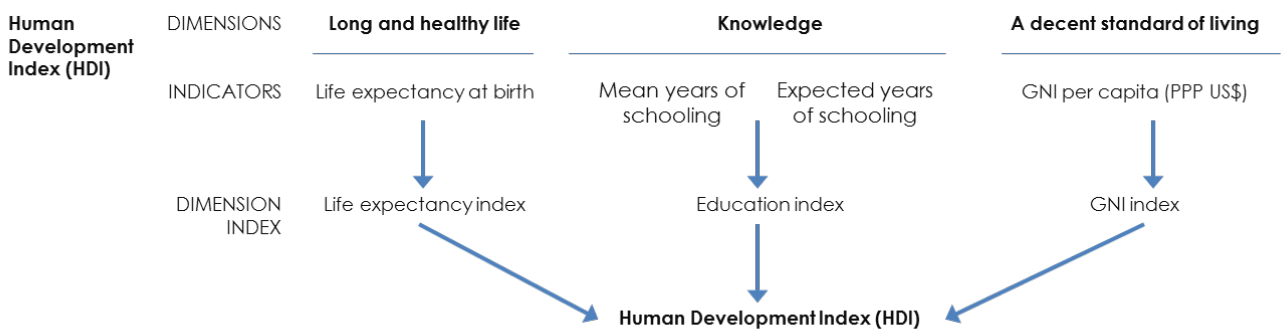
### *Human Development Index*

The model also calculates the Human Development Index (HDI). The HDI is considered an alternative indicator to GDP per capita as a measure of economic development and quality of life. The HDI is based on three dimensions:

1. A long and healthy life, as measured by life expectancy at birth
2. Educational attainment, as measured by mean years of schooling for adults ages 25 years and older and expected number of years of education achieved
3. A decent standard of living, as measured by GDP per capita adjusted for purchasing power parity

The HDI framework is shown in Figure 5. The specific equations to calculate the HDI and country-specific rankings are found in annual Human Development Reports (United Nations Development Program, 2011). Three sub-indices (each accounting for one-third of the total score value) constitute the index: life expectancy, education, and income. Some of the necessary components of the HDI are calculated by DemDiv and the others are input by the user, so changes in a country's HDI ranking are among the model's results.

**Figure 5. Human Development Index**




### *Model Limitations*

Like any model, DemDiv has its limitations, and users should be aware of these. First, the statistical relationships that underlie the behavioral equations (e.g., TFP, employment, investment, and child mortality) were estimated using international cross-sectional data and are assumed not to change over time. In addition, the cross-sectional relationships are assumed applicable to any country in the dataset.

These are strong assumptions, but not unprecedented. Other models (e.g., Ashraf et al., 2013) use micro-level data from a variety of sources to draw general conclusions that may not be applicable to a specific country.

Second, some linkages between population growth and the economy have not been incorporated into the model. These include childcare effects on labor supply, population-induced technical progress ("Boserup" effects), and the role of land in production, among others.

Third, the economic model is a single-sector model. A two- or three-sector model that accounts for shifts in production, demand, and labor supply among multiple sectors (most obviously, agriculture and non-agriculture) may capture more sophisticated dynamics. In low-income countries, subsistence agriculture may serve as a default industry that absorbs excess labor, keeping absolute unemployment rates low, but also providing low wages and low productivity that do not generate significant economic growth. In developing DemDiv, we opted for a simpler model because of the ease of communicating its structure and results to users. However, we will continue to explore options for adding a multiple sector approach to future iterations of DemDiv.

Finally, while the model includes equations to estimate two important factors of production—employment and capital—it is a partial equilibrium model and so does not model the labor and capital markets as would be the case with a computable general equilibrium model.

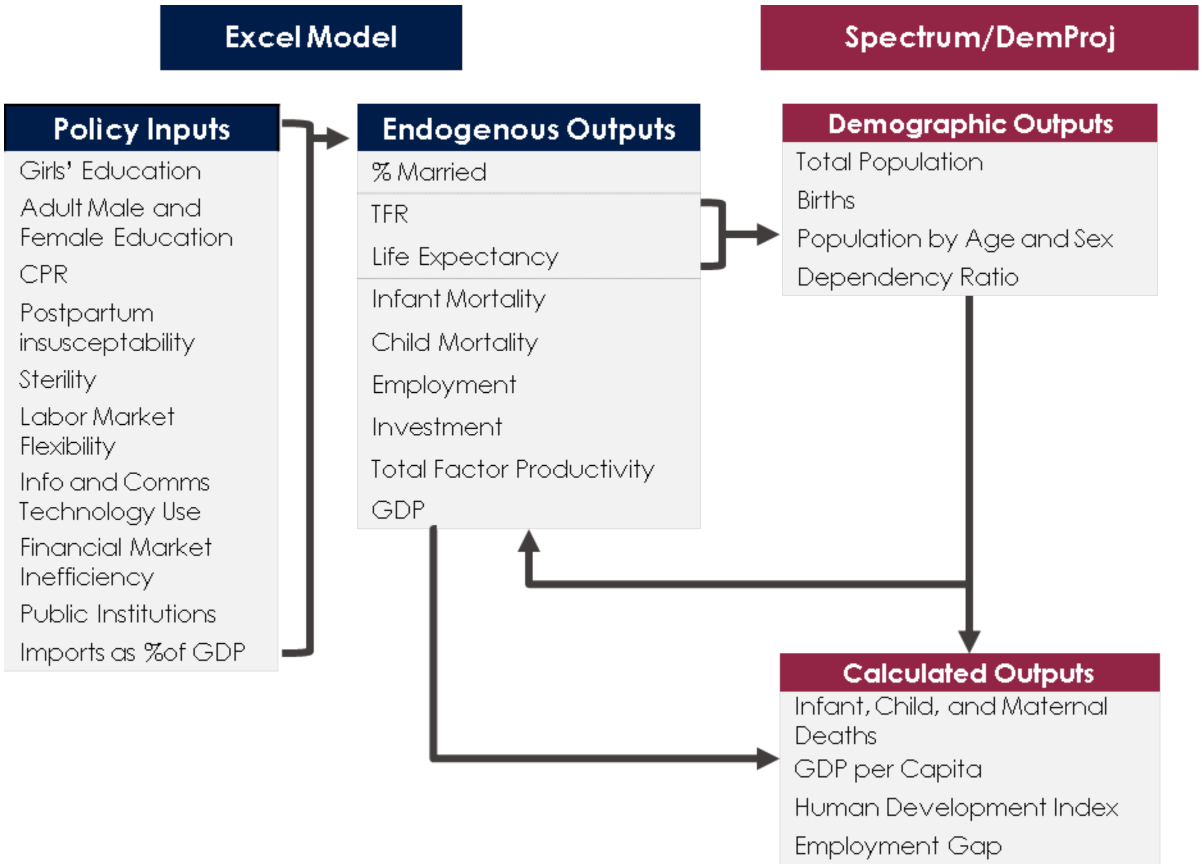
# USERS' MANUAL

The current version of DemDiv uses a hybrid software approach that combines an Excel model with the DemProj component of the Spectrum system of models.[1] Figure 6 shows how the two models are linked. To complete a projection, three steps are involved:

1. Initially, a user auto-generates default data—or enters his/her own—for all base year values in the DemDiv Microsoft Excel file. Users can set targets for the policy inputs for up to four projection scenarios. The Excel model then uses these base year and projected values to calculate the demographic outputs of TFR and life expectancy over the projection period.
2. Through the RAPID Transfer Tool in Spectrum, the user links the Excel model to DemProj, which uses TFR and life expectancy at birth to project births and the population size and structure over the specified time period.
3. Key population variables calculated by DemProj are subsequently fed directly back to the Excel model and used to calculate the model's economic variables such as GDP per capita, the employment gap, and impacts on child and maternal mortality. The HDI is also calculated during this step.

[1] Available for free download: http://spectrumbeta.futuresinstitute.org/SpecInstall.EXE and http://futuresinstitute.org/Download/Spectrum/CountryDataInstall.EXE.

**Figure 6. DemDiv Computer Model Structure**




### *DemDiv Model Structure*

The Excel-based model has several worksheets that have been pre-programmed for different functional areas while providing maximum flexibility and options for customization. DemDiv allows the user to design up to four future scenarios based on different policy inputs. The first, the "base scenario," is meant to be a scenario where there is little change compared to the present. This can be used as a "business-as-usual scenario." The user can adjust this scenario so that everything stays the same (i.e., all policy variables remain constant at base year levels over the entire projection period) or that policy variables improve incrementally, perhaps matching historic rates of change. The other three policy scenarios are designed so that the user can set future target values for the policy inputs in any combination desired. For example, one policy scenario could reflect changes in economic policy variables only; the second, changes in economic and education policy variables only; and the third might add family planning to reflect combined changes in all three policy areas. This would allow the user to see the demographic dividend clearly: that is, the portion of changes in economic variables that are a result of family planning's effects on age structure. However, if the user prefers, the base scenario can also be used to design a policy scenario. Additionally, users can select to apply only one or two policy scenarios instead of three.

The Excel model begins with a master worksheet, labeled **Control**, which is the worksheet through which the user interacts with the model. In this sheet, the user selects the country of analysis, generates default data for the model's variables (where available), enters additional initial base year values (where necessary), and defines the end values of the policy input variables.

The model contains several other Excel worksheets that DemDiv uses for calculations, which are not directly altered or changed by the user. These include four worksheets that solve the model for each scenario: **Base Scenario**, **Policy Scenario-1**, **Policy Scenario-2**, and **Policy Scenario-3**. These four worksheets contain two main panels. The first panel calculates the interpolated values for the length of the projection for each of the policy variables that are set in the **Control** worksheet. The second panel contains the calculated values for each period for the model's demographic and economic output variables.[2]

The two worksheets labeled **To Demproj** and **Population** are used by DemDiv to organize and handle the data flow between the Excel model and DemProj within Spectrum. The **Child Survival** and **Maternal Mortality** worksheets automatically calculate infant, child, and maternal deaths under each scenario, and the **HDI** worksheet calculates a country's HDI value. These sheets are locked, and the user does not enter data into any of them. The Excel model also includes several worksheets that present graphs of the model's main variables which the user can manipulate and, if desired, use to present and disseminate the model's results.

## *Configuration*

### *Step 1: Establish Initial Values*

To use DemDiv, the user first needs to open the default Excel file[3] and enable macros in Excel. Macros are enabled by selecting "Enable Content" in the yellow message bar with a shield icon upon opening the Excel workbook (see Figure 7). Next, the user must select the country of analysis from the drop-down menu on the **Control** worksheet. The model is constructed so that default data drawn from the **Data Base** worksheet automatically populate the initial year (baseline) value fields based on the country selection (column C, rows 5, 14, and 18), where available. Figure 7 provides an example using Kenya as the country of analysis. The initial values include 14 policy variables in three areas (education, family planning, and economic policies, described in Step 2) and 19 additional baseline values:

- Percent married/in union
- Total fertility rate (TFR)
- Births at any risk (%)
- Infant mortality rate (IMR)
- Under-five morality rate (U5MR)
- Maternal mortality ratio (MMR)
- Contraceptive effectiveness, modern and traditional methods
- Female life expectancy
- Capital formation per capita
- Employment
- Employment growth rate
- GDP per capita
- Ratio of capital stock to population 15+ (per capita)
- GDP growth rate

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[2] The model automatically adjusts the calculated first period values of these variables to correspond to their base year values. This is necessary because the statistical regression equations that are used to project the model's outputs would not predict the actual first period value (the error term). Essentially, we adjust the regression's constant term so that the base year value is returned.

[3] Available for free download at http://www.healthpolicyproject.com/index.cfm?id=software&get=DemDiv.

- Capital stock growth rate
- Female-male life expectancy difference
- Capital stock depreciation rate
- Primary education costs as a percentage of GDP per capita
- Labor force participation rate

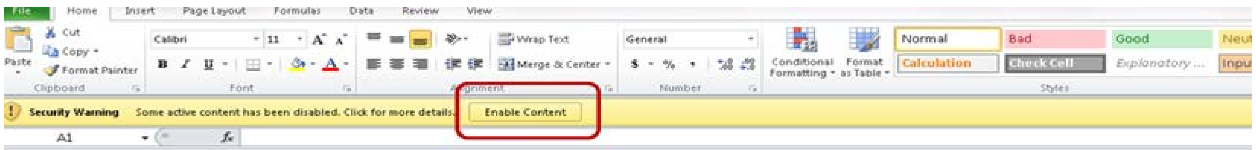
The user may change/update any of the auto-populated initial values. Default source information for each of these variables is provided below the related cell on the **Control** worksheet. All data required in this step are available from standard international sources, included in the **Data Base** and auto filled once the user selects the country of interest. Some countries do not have full coverage of data from the sources used in the **Data Base**. In this case, after the user selects the country from the drop-down menu on the **Control** sheet, the cells for variables without available data will remain blank. The user will then have to locate alternate data sources for the model to function properly. Other data may be drawn from national sources or other references identified by the user and/or technical working group members, if applicable.

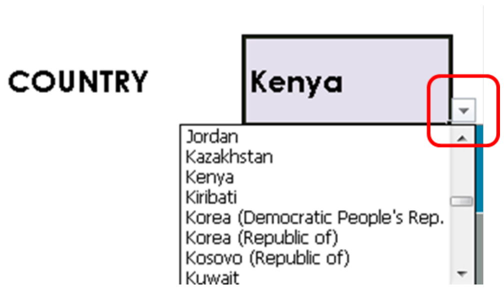
In addition, the **Control** sheet includes two columns in which the user can enter his/her own figures for base year population by age and sex (columns C–D, rows 24–40). DemDiv will automatically use the initial year data for the selected country in DemProj. These data are drawn from the most recent revision of *World Population Prospects*, published by the United Nations Population Division. However, this optional feature allows the user to input a figure from an alternate data source, such as a census, if desired. If the user completes these cells with alternate data, DemDiv will automatically use those data. If the cells remain blank, DemDiv will maintain use of the DemProj default data.[4]

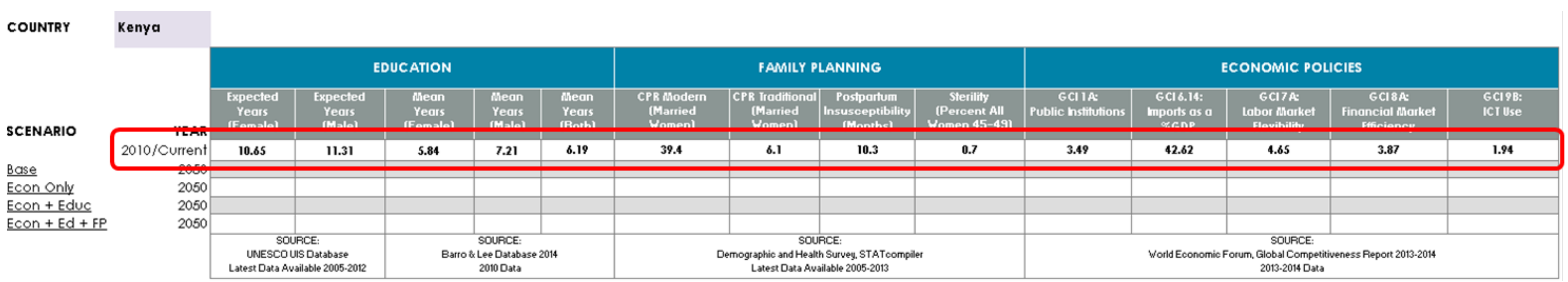
[4] Because of this feature, the beta version of Spectrum must be applied for the model to work successfully. It can be downloaded at http://spectrumbeta.futuresinstitute.org/SpecInstall.EXE.

**Figure 7. Entering Base Year Values**

*Enabling Macros*



COUNTRY: Kenya

| SCENARIO | YEAR | EDUCATION | | | | | FAMILY PLANNING | | | | ECONOMIC POLICIES | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Expected Years (Female) | Expected Years (Male) | Mean Years (Female) | Mean Years (Male) | Mean Years (Both) | CPR Modern (Married Women) | CPR Traditional (Married Women) | Postpartum Insusceptibility (Months) | Sterility (Percent All Women 45-49) | GCI 1A: Public Institutions | GCI 6.14: Imports as a %GDP | GCI 7A: Labor Market Flexibility | GCI 8A: Financial Market Efficiency | GCI 9B: ICT Use |
| | 2010/Current | 10.65 | 11.31 | 5.84 | 7.21 | 6.19 | 39.4 | 6.1 | 10.3 | 0.7 | 3.49 | 42.62 | 4.65 | 3.87 | 1.94 |
| Base | 2050 | | | | | | | | | | | | | | |
| Econ Only | 2050 | | | | | | | | | | | | | | |
| Econ + Educ | 2050 | | | | | | | | | | | | | | |
| Econ + Ed + FP | 2050 | | | | | | | | | | | | | | |
| | | SOURCE: UNESCO UIS Database Latest Data Available 2005-2012 | | SOURCE: Barro & Lee Database 2014 2010 Data | | | SOURCE: Demographic and Health Survey, STATcompiler Latest Data Available 2005-2013 | | | | SOURCE: World Economic Forum, Global Competitiveness Report 2013-2014 2013-2014 Data | | | | |

### *Step 2: Define Policy Scenarios*

The second step in using the model is to establish policy scenarios in the **Control** sheet of the Excel model (Rows 6–9). Figure 8 gives an example using data from Kenya, with the policy scenarios completed in the way that they were originally conceived of in the model.

In the example shown in Figure 8, the Base Scenario simply holds all policy variables constant over the time period of the projection, as described above. The results of this scenario inform the user what demographic, health, and development changes can be expected if the status quo continues (i.e., with no changes in the current policy environment). Policy Scenario 1, labeled Econ Only, is designed so that the user enters changes in the economic policy variables, but holds all other variables constant. Policy Scenario 2, labeled Econ + Educ, layers changes in the education variables on top of the Econ Only scenario, holding the family planning variables constant at the baseline levels. Finally, Policy Scenario 3, labeled Econ + Ed + FP, is a combined scenario in which all policy variables are changed. This scenario typically produces the most pronounced changes in demographic, health, and development outcomes because of the multiplicative effects that the policy variables have with each other. In this example, Policy Scenario 3 also clearly delineates the demographic dividend, or economic benefits attributable to changes in population age structure.

Initial pilot applications of DemDiv have shown that these default parameters produce distinct results for each policy scenario that can be readily communicated to policymakers. However, the user is free to adjust the parameters of every scenario to suit the context of a given application. The user is also not required to set values for all four possible scenarios. If the user wishes to apply fewer than four scenarios, s/he should leave the unnecessary scenario rows in the **Control** sheet blank. The user should then ignore the worksheets listing results from the policy scenarios that were not utilized. This may require the user to adjust the graphs that DemDiv generates so that data from the unused scenarios are not shown.

To create a scenario, the user specifies an end value for each of the 14 policy variables in the end year of the projection:

- Expected years of education (female)
- Expected years of education (male)
- Mean years of education (female)
- Mean years of education (male)
- Mean years of education, both sexes
- CPR, modern methods (married/in-union women)
- CPR, traditional methods (married/in-union women)
- Postpartum insusceptibility
- Sterility
- GCI 1A: Public institutions
- GCI 6.14: Imports as a percentage of GDP
- GCI 7A: Labor market flexibility
- GCI 8A: Financial market efficiency
- GCI 9B: ICT use

The end value for these variables is often set at an optimistic yet achievable level, balancing the significant changes needed in most high-fertility countries to generate a demographic dividend with the feasibility of such changes given available and required resources. In some cases, national development plans, sector policies, and other documents will offer specific goals and targets that can be adopted for the policy scenarios of DemDiv.

The default final year in the Excel model is set at 2050, and the base year default is set at 2010. However, these years can be changed by the user to match any 40-year projection period. In general, DemDiv interpolates linearly between the base year and final year. The model projects results for every individual year over the projection period, so the user can readily apply the model for a period shorter than 40 years if desired. To do this, the user would simply only view and disseminate results for the years of interest. However, extending the projection period beyond 2050 would require re-programming the full model, and is not an available feature at this time.

**Figure 8. Defining Policy Scenarios**

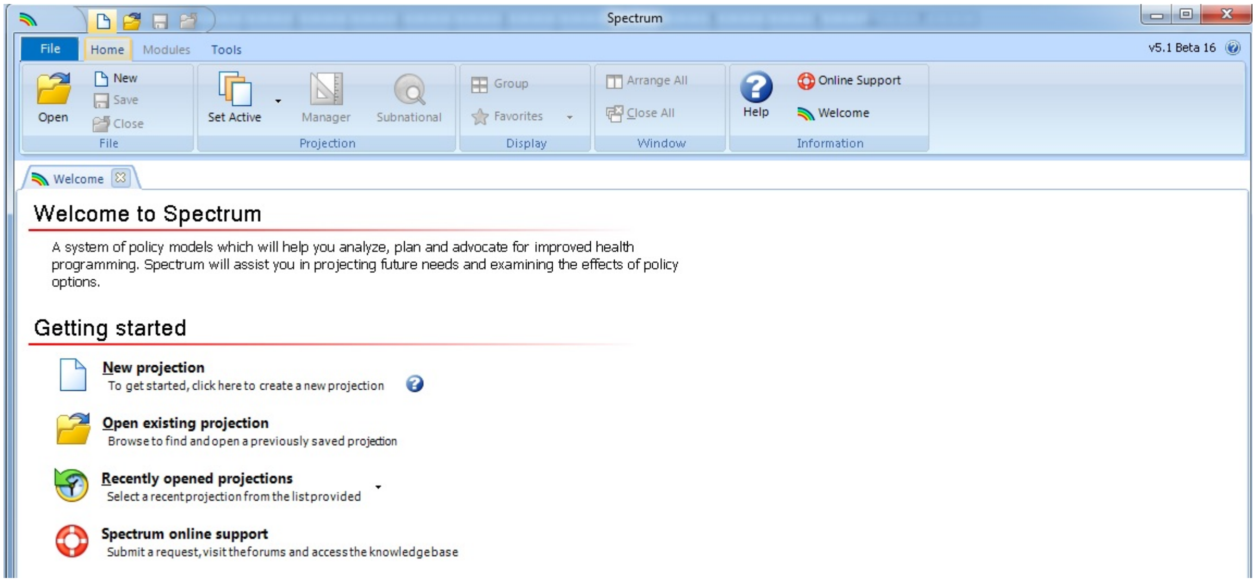
| COUNTRY | Kenya | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | EDUCATION | | | | | FAMILY PLANNING | | | | ECONOMIC POLICIES | | | | |
| SCENARIO | YEAR | Expected Years (Female) | Expected Years (Male) | Mean Years (Female) | Mean Years (Male) | Mean Years (Both) | CPR Modern (Married Women) | CPR Traditional (Married Women) | Postpartum Insusceptibility (Months) | Sterility (Percent All Women 45-49) | GCI 1A: Public Institutions | GCI 6.14: Imports as a %GDP | GCI 7A: Labor Market Flexibility | GCI 8A: Financial Market Efficiency | GCI 9B: ICT Use |
| | 2010/Current | 11.00 | 11.00 | 5.44 | 7.10 | 6.27 | 39.4 | 6.0 | 10.3 | 0.7 | 3.49 | 42.62 | 4.65 | 3.87 | 1.94 |
| Base | 2050 | 11 | 11 | 5.44 | 7.10 | 6.27 | 39.4 | 6.0 | 10.3 | 0.7 | 3.49 | 42.62 | 4.65 | 3.87 | 1.94 |
| Econ Only | 2050 | 11 | 11 | 5.44 | 7.10 | 6.27 | 39.4 | 6.0 | 10.3 | 0.7 | 4.71 | 29.83 | 4.89 | 4.90 | 5 |
| Econ + Educ | 2050 | 16 | 16 | 11 | 11.50 | 11.25 | 39.4 | 6.0 | 10.3 | 0.7 | 4.71 | 29.83 | 4.89 | 4.90 | 5 |
| Econ + Ed + FP | 2050 | 16 | 16 | 11 | 11.50 | 11.25 | 70.0 | 2.0 | 10.3 | 0.7 | 4.71 | 29.83 | 4.89 | 4.90 | 5 |
| | | SOURCE: UNESCO UIS Database Latest Data Available 2005-2012 | | SOURCE: Barro & Lee Database 2014 2010 Data | | | SOURCE: Demographic and Health Survey, STATcompiler Latest Data Available 2005-2013 | | | | SOURCE: World Economic Forum, Global Competitiveness Report 2013-2014 2013-2014 Data | | | | |

### *Step 3: Project the Population*

The third step is to run the RAPID Transfer Tool in Spectrum to perform population projections. This step pulls outputs for life expectancy and fertility from DemDiv's Excel model into DemProj, where they are used as inputs for population projections. Several key demographic variables are then exported back to the Excel model from DemProj. Almost all of the work for this step is completed automatically by the two models; the user only needs to set up the communication between them.

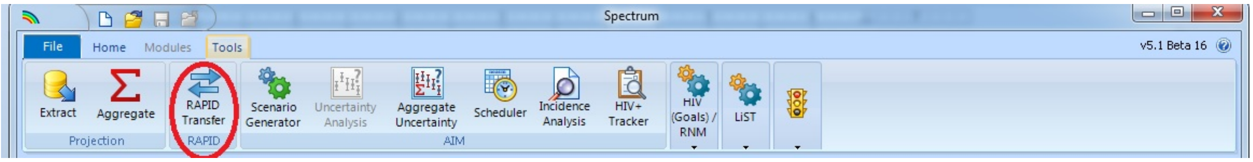
First, the user should open Spectrum (see Figure 9). If not already installed, Spectrum can be downloaded free of charge, together with the accompanying Country Data Pack.

**Figure 9: Opening Spectrum**



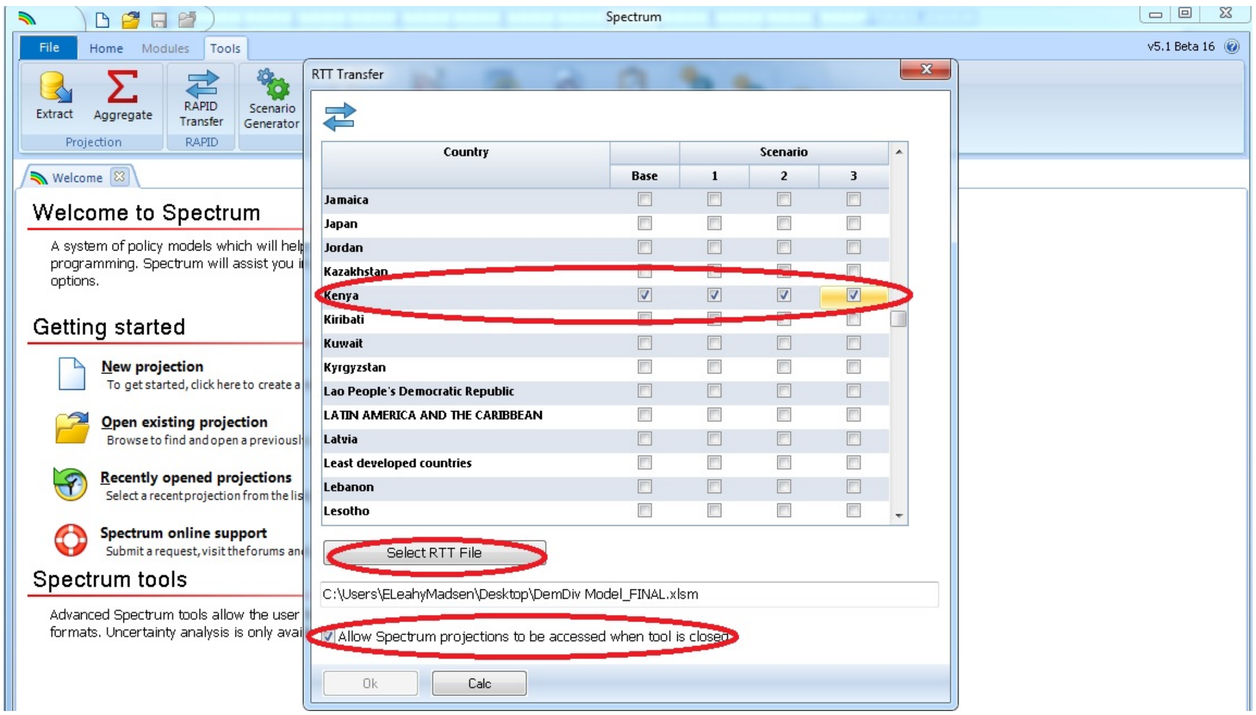

Unlike other Spectrum applications, the user should not open or create any Spectrum files. The user should open the **Tools** page and select the **RAPID Transfer** (see Figure 10):

**Figure 10: RAPID Transfer Tool**



Once the RAPID Transfer Tool is opened, select a country by clicking all four scenarios for the country chosen and select the DemDiv Excel file to be used (see Figure 11). Even if the user has chosen to apply fewer than four scenarios, all four boxes must be checked for the tool to work properly. The Excel file must be closed at this stage.

**Figure 11: Applying the RAPID Transfer Tool**



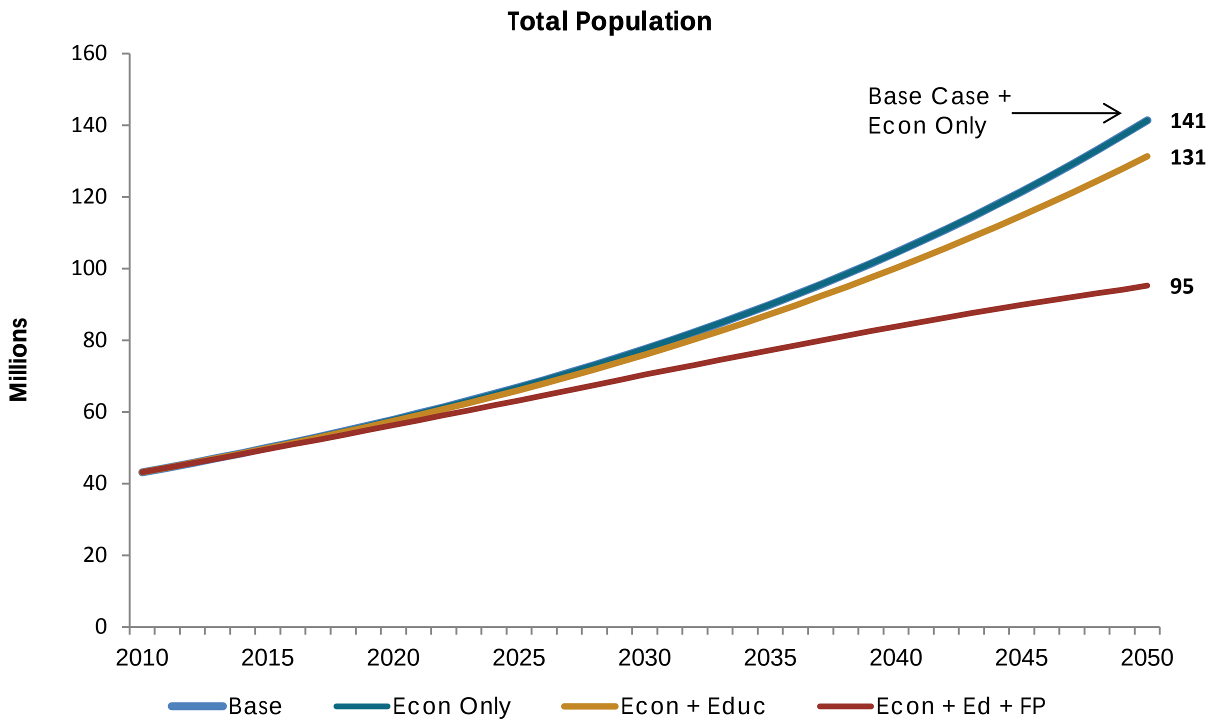

Once this step is completed, click on "Calc." RAPID Transfer will automatically run the four population projections through DemProj as described above. There is no need to open DemProj or otherwise make any changes in Spectrum.

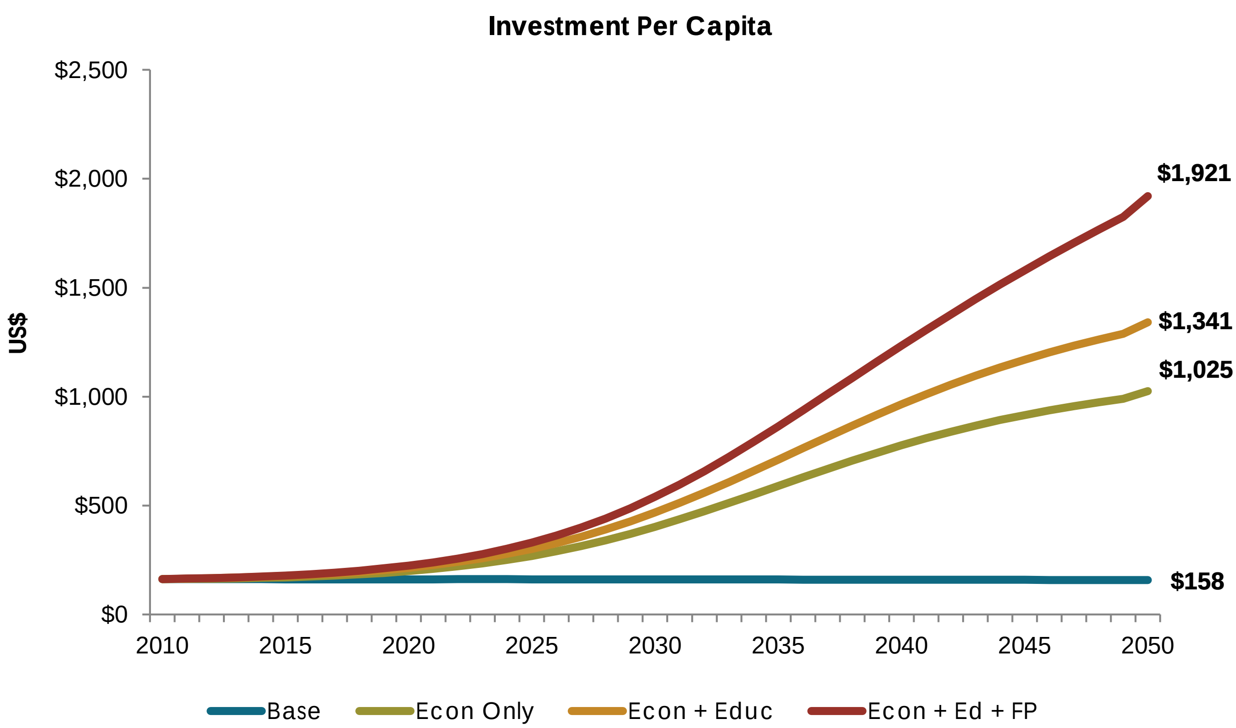
When using the RAPID Transfer Tool option in Spectrum, no Spectrum files can be open. However, if the user wishes to open the Spectrum projections after the calculations are made, check the "Allow Spectrum projections to be accessed when tool is closed" box at the bottom of the page before clicking on the "Calc" button (see Figure 11). After completion of this step, the user should close Spectrum and choose "Yes" to save the projection files generated by Spectrum. They will automatically be saved in the same location as the Excel file.

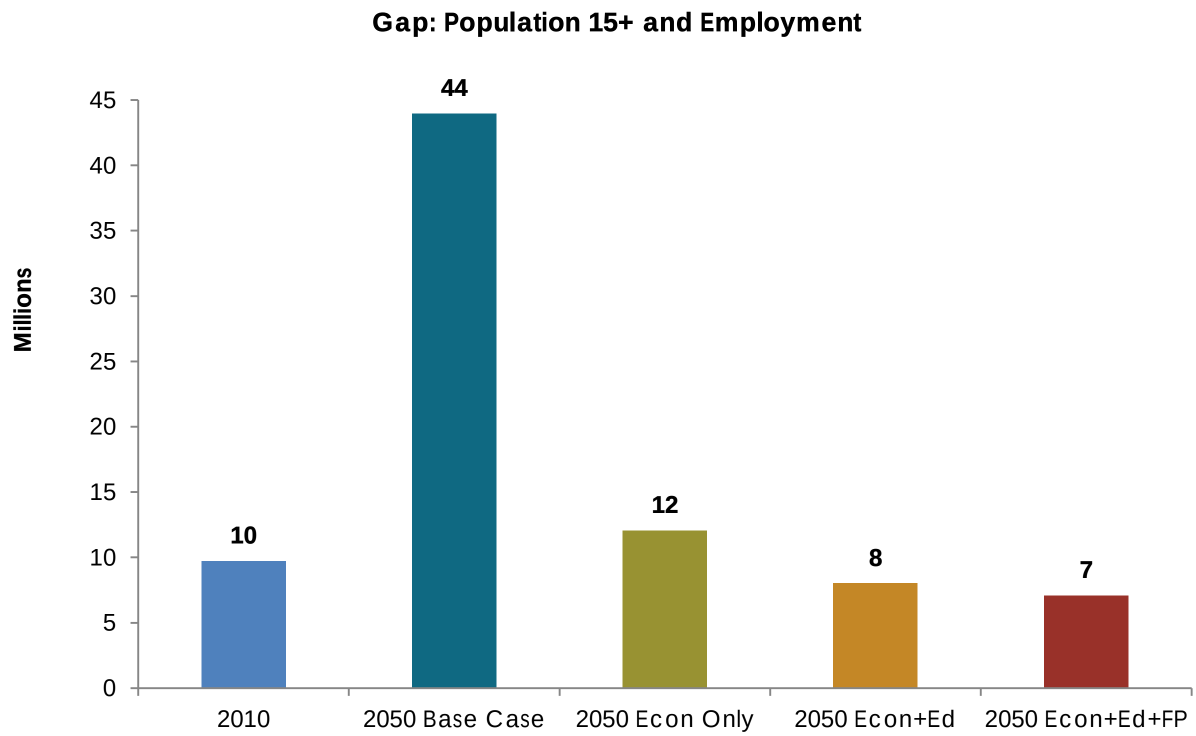
### *Step 4: View the Results*

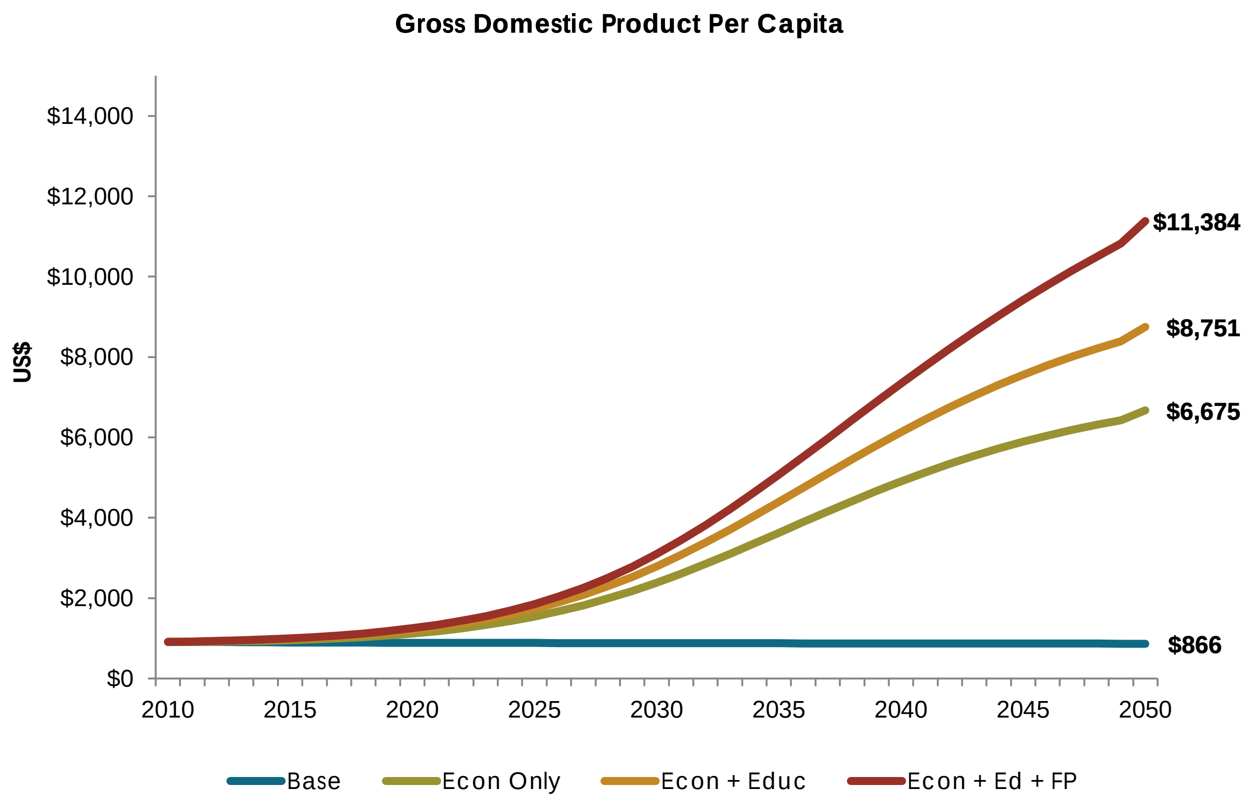
Users can view the numerical results by looking at the projections in each of the calculated worksheets (**Base Scenario**, **Policy Scenario-1**, **Policy Scenario-2**, **Policy Scenario-3**, **Population**, **Child Survival**, and **Maternal Mortality**). In addition, the user can view some of the major outputs with the graphs that are automatically generated; Figure 12 shows four sample results graphs.

**Figure 12: Sample DemDiv Results Graphs**




Gap: Population 15+ and Employment
Millions
45
40
35
30
25
20
15
10
5
0
44
10
12
8
7
2010
2050 Base Case
2050 Econ Only
2050 Econ+Ed
2050 Econ+Ed+FP


Gross Domestic Product Per Capita
US$
$14,000
$12,000
$10,000
$8,000
$6,000
$4,000
$2,000
$0
$11,384
$8,751
$6,675
$866
2010
2015
2020
2025
2030
2035
2040
2045
2050
Base
Econ Only
Econ + Educ
Econ + Ed + FP

# APPENDIX A. DATA DEFINITIONS AND SOURCES

Data from 251 countries and territories were used to build the DemDiv model, although not all countries had complete data for each variable. Key variables used to build the model and the data source for each are defined below, with variables for the demographic and economic models grouped together (Table A1). When the user applies DemDiv, data for all required variables are auto-populated from the Data Base, and the default source and date for each is clearly labeled on the Control worksheet. Alternate data sources for the baseline and policy variables can be used if desired.

**Table A1: Key Variable Definitions**

*Demographic Model*

| Variable | Description | Source | Year |
|---|---|---|---|
| **Education** | | | |
| **Expected Years of Female/Male Education** | Total number of years of schooling a female/male child today can expect to receive, assuming that the probability of her/him being enrolled in school at future ages is equal to the current enrollment rate at those ages | United Nations Statistics Division. 2014. "Social Indicators: Table 4e, School Life Expectancy." Updated December 2012. *https://unstats.un.org/unsd/demographic/products/socind/default.htm.* | 2009 |
| **Mean Years of Female/Male Education** | Average number of years of schooling attained for females/males currently age 25 or older | Barro, Robert and Jong-Wha Lee. 2013. "A New Data Set of Educational Attainment in the World, 1950–2010." *Journal of Development Economics* 104(September): 184–198. *http://www.barrolee.com/data/dataexp.htm* | 2010 |
| **Mean Years of Education (Both Sexes)** | Average number of years of schooling for the population ages 25 years and older (average of male and female values) | Barro and Lee, 2013 *http://www.barrolee.com/data/dataexp.htm* | 2010 |
| **Family Planning** | | | |
| **Contraceptive Prevalence Rate** | Percentage of currently married women using any method of family planning | ICF International. "The DHS Program: Demographic and Health Surveys." *http://www.dhsprogram.com/* | Most recent |
| **Postpartum Insusceptibility** | Median number of months of postpartum insusceptibility for births in three years preceding survey | ICF International *http://www.dhsprogram.com/* | Most recent |
| **Sterility** | Percentage of married women ages 45–49 with no children ever born | ICF International *http://www.dhsprogram.com/* | Most recent |

| **Other Demographic Indicators** | | | |
|---|---|---|---|
| **Percentage Married (women)** | Percentage of women currently married | ICF International<br>*http://www.dhsprogram.com/* | Most recent |
| **Total Fertility Rate** | Total fertility rate for three years preceding the survey and percentage of women ages 15–49 currently pregnant | ICF International<br>*http://www.dhsprogram.com/* | Most recent |
| **Percentage High-Risk Births** | Percentage of births in five years preceding the survey with any risk factor (mother over age 34 or under age 18 at time of delivery; birth order greater than 3; and/or birth occurring within 24 months of preceding birth) | ICF International<br>*http://www.dhsprogram.com/* | Most recent |
| **Infant Mortality Rate** | Infant deaths (under 1 year of age) per 1,000 live births | ICF International<br>*http://www.dhsprogram.com/* | Most recent |
| **Under-5 Mortality Rate** | Child deaths (under age five) per 1,000 live births | ICF International<br>*http://www.dhsprogram.com/* | Most recent |
| **Maternal Mortality Ratio** | Maternal deaths per 100,000 live births | ICF International<br>*http://www.dhsprogram.com/* | Most recent |
| **Female Life Expectancy** | Average number of years a newborn female is expected to live if current age-specific mortality rates remain constant | United Nations. 2013. *World Population Prospects: The 2012 Revision.* New York: United Nations Population Division.<br>*http://esa.un.org/unpd/wpp/unpp/panel_population.htm* | 2005–2010 |

*Economic Model*

| Variable | Description | Source | Year |
|---|---|---|---|
| **Investment** | | | |
| **Fixed Capital Formation (per capita)** | Fixed capital formation in current US$, divided by mid-year population. Includes land improvements; equipment purchases; construction of roads, railways, schools, offices, hospitals, residential dwellings, commercial and industrial buildings; net acquisitions of valuables | World Bank. "World Development Indicators." *http://data.worldbank.org/indicator* | 2010 |
| **Gross Domestic Product (per working age adult)** | Gross domestic product in current US$ divided by mid-year population. Sum of gross value added by all resident producers in the economy; no deductions for depreciation of fabricated assets or depletion of natural resources | World Bank *http://data.worldbank.org/indicator* | 2010 |
| **Working Age Population (per capita)** | Population ages 15 and older, divided by mid-year population | United Nations, 2013 *http://esa.un.org/wpp/Excel-Data/population.htm* | 2010 |
| **Financial Market Efficiency** | Measurement (on a scale of 1–7, with 7 as highest possible score) of efficiency of financial market, including factors such as availability and affordability of financial services, financing through local equity market, ease of access to loans and venture capital availability<br>Pillar 8A in GCI database | Schwab, K., ed. 2012. *The Global Competitiveness Report 2012–2013: Full Data Edition.* Geneva: World Economic Forum *http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2013-14.pdf* | 2012–2013 |
| **Employment** | | | |
| **Employment and Change in Employment** | Number of employed persons (ages 15 and up) and average annual percent change in this number during 2006–10 | International Labor Organization (ILO). 2013. *Key Indicators of the Labour Market (KILM), Seventh Edition*. Geneva: ILO. *http://ilo.org/empelm/pubs/WCMS_114060/lang--en/index.htm* | 2006–2010 |
| **Change in Working-age Population** | Average annual percent change in working-age population between 2006 and 2010 | United Nations, 2013 *http://esa.un.org/wpp/Excel-Data/population.htm* | 2006–2010 |

| | | | |
|---|---|---|---|
| **GDP Percent Growth** | Average annual GDP percent growth between 2006 and 2010 | World Bank<br>*http://data.worldbank.org/indicator* | 2006–2010 |
| **Labor Market Flexibility** | Measurement (on a scale of 1–7) of labor market flexibility, including factors such as labor-employer relations, wage flexibility, hiring and firing practices, and effects of taxation<br>Pillar 7A in GCI database | Schwab, ed., 2012<br>*http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2013-14.pdf* | 2012–2013 |
| **Productivity** | | | |
| **Public Institutions** | Measurement (on a scale of 1–7) of public institution strength, including factors such as property rights, ethics and corruption, independence, government efficiency, and security<br>Pillar 1A in GCI database | Schwab, ed., 2012<br>*http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2013-14.pdf* | 2012–2013 |
| **Information and Communication Technologies Use** | Measurement (on a scale of 1–7) of use and capacity of Internet and mobile phone infrastructure<br>Pillar 9B in GCI database | Schwab, ed., 2012<br>*http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2013-14.pdf* | 2012 |
| **Imports as % of GDP** | Imports of goods and services as a percentage of GDP<br>Pillar 6.14 in GCI database | Schwab, ed., 2012<br>*http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2013-14.pdf* | 2012 |
| **Other Economic Indicators** | | | |
| **Capital Stock** | Physical capital stock in an economy (e.g., machinery, buildings, computers) | Berlemann, M. and J-E. Wesselhöft. 2012. *Estimating Aggregate Capital Stocks Using the Perpetual Inventory Method – New Empirical Evidence for 103 Countries.* Hamburg: Helmut Schmidt University | 2010 |
| **Labor Force Participation Rate (for model application only)** | Percentage of the population ages 15 and older who are economically active (i.e., employed, formally or informally, or seeking employment) | By default, this is set to 1, equating to a labor force participation rate of 100%, in DemDiv<br>ILO, 2013<br>*http://www.ilo.org/empelm/what/WCMS_114240/lang--en/index.htm* | User-selected |

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