APPENDIX I
The USAID Demographic Dividend Model

Bloom and Williamson (1998) constructed an empirical growth model containing demographic variables in order to illustrate the contribution that the demographic transition of East Asian economies had on their economic growth. Following this study, the examination of the demographic dividend started to include the use of simulation models, especially in countries that had not yet achieved the necessary demographic transitions. In 2013, Ashraf et al. (2013) developed a simulation model that examined the effect of fertility changes on output per capita, while the International Monetary Fund (IMF) developed an econometric model to quantify the potential size of the sub-Saharan African demographic dividend (Drummond et al. 2014). The results obtained by the IMF model were similar to those found by Bloom et al. (2013 and 2014), who established cross-country economic growth equations within an empirical simulation model for Nigeria. The results illustrated a significant impact on GDP per capita through the reduction of unmet family planning needs in the country. In 2015, Canning et al. constructed a macro-simulation model using Nigerian data following the framework produced by Ashraf et al. (2013). In this model, the authors compare the impact of declining fertility rates on key economic and demographic outcomes through the use of various alternative scenarios. It was shown that GDP per capita in Nigeria would be higher under lower fertility rates than higher rates. A similar approach was taken by Mason et al. (2016), in which the impact of various fertility scenarios was estimated on consumption per capita.

Drawing on this literature, a model was developed under the USAID-funded Health Policy Project, the aim of which was to understand the conditions under which a country could potentially benefit from a demographic dividend – the DemDiv model.¹ The analysis in this report draws upon the concepts laid out in the USAID Demographic Dividend model, which uses the idea that population growth and economic growth are closely related, and that proper policy structuring can help a country attain increased economic gains during these periods of population expansion.

The model utilises effects from changing demography and dependency rates, savings rates, and labour productivity to project demographic and economic changes of a given country for the next 40 years. Based on estimations from multiple linear regressions using a cross-country database, USAID models demographic and economic indicators and quantifies how those changes affect population projections and other economy-wide indicators. In order to do this, the model is divided into two sub-models: the demographic sub-model and the economic sub-model (Figure A1). The former sub-model uses basic indicators such as expected school life expectancy and modern contraceptive prevalence rate (CPR) to model life expectancy, fertility and child mortality, and feeds into the latter sub-model, which estimates changes in education, the composition of the labour force, productivity, and capital stock to derive an estimated GDP per capita in each period.

¹ (Moreland et al. 2014)
FIGURE A1. THE DEMOGRAPHIC (TOP) AND ECONOMIC (BOTTOM) SUB-MODELS

From here, USAID uses Spectrum, a software program which operates using the USAID Model inputs, to take the endogenous outputs of the total fertility rate (TFR) and life expectancy at birth to project births, population size and structure, as well as dependency ratios. This software provides several analytical tools to policymakers in order to aid the decision-making process. To complete a projection using Spectrum, three main steps are involved under the original USAID DemDiv model: (i) enter data for all base year values along with set targets for policy inputs into the DemDiv model in order to calculate demographic outputs; (ii) link the USAID DemDiv model to the DemProj model through the RAPID Transfer Tool in Spectrum in order to project births, population size and population structure over a defined period; and (iii) gain DemProj calculated key population variables, which are fed back into the USAID DemDiv model in order to calculate the economic variables of the model (e.g. GDP per capita, employment gap, etc). The numerical results can subsequently be examined in the USAID DemDiv model, while major outputs are graphically displayed in Spectrum. The resulting estimations then allow for the computation of the demographic dividend for a base case and two different policy scenarios, which require entering aspirational target values for policy indicators in the areas of education, family planning and the wider economy for the final year of the projection.

Once the three scenarios are established, the demographic dividend can be measured. To do so, it is vital to determine which scenarios to compare and what metrics to use. The choice of comparison depends on what the government is advocating for. In terms of metrics, the most commonly used ones include GDP per capita and the growth rate of GDP per capita. Other metrics that have been used in previous literature include: the growth rate of per capita consumption, the growth rate of capital stock, as well as the poverty headcount (%). As is evident, the majority of metrics used are based on a per capita basis as they are intuitive and popular. However, Moreland (2017) has argued that the use of per capita metrics has limitations as they include a denominator effect – the indicator may increase simply as a result of a reduction in the denominator (population) as a result of a decline in fertility – and therefore may not be the most suitable metric when measuring the demographic dividend. Thus, careful interpretation of per capita indicators is required when drawing conclusions.

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2 Based on assumptions about fertility, mortality and migration, the DemProj model, a cohort-component population projection model, in Spectrum projects the population of a country/region by sex and age for up to 50 years into the future. The projection creates a full set of demographic indicators. This can be done for rural and urban areas separately.

3 Education policy indicators include the expected and mean years of education by gender; family planning policy indicators use proximate determinants of fertility such as the contraceptive prevalence rate, Postpartum insusceptibility and sterility; while economic policy indicators include five indices from the World Economic Forum’s Global Competitiveness Report (public institutions, imports as a percentage of GDP, labour market flexibility, financial market efficiency, and ICT use).

APPENDIX II

METHODOLOGICAL REVIEW

When modelling expenditure or resource requirements to achieve a development outcome, various existing methodologies can be used, including the unit-cost approach, the Computable General Equilibrium Models (CGE), the Maquette for MDG Simulations, the Integrated Assessment Models (IAMs), etc. The report at hand has focused particularly on providing an innovative methodology in order to explicitly quantify the cross-sectoral synergies present in the Ugandan economy, which the original version of the USAID DemDiv model does not address. In order to do so, the econometric model utilizes a public policy production function that models joint production, whose results are subsequently inserted into a modified version of the USAID DemDiv model.

The modification of the DemDiv model was necessary as, although the original USAID DemDiv model is built upon simulation and econometric models employed by Coale and Hoover (1958), Bloom et al. (2010) and Ashraf et al. (2013), several shortcomings could still be identified. First, the original methodology does not model concrete policies. Instead it assumes policy outcomes in the areas of education, family planning and economics up until 2050. Secondly, it does not specify how these assumed outcomes are to be achieved and at what cost for the Government of Uganda (GoU). Thirdly, it relies on cross-country regression analyses to define relationships between inputs and outcomes, while not accounting for differences in outcomes across countries or time. Fourthly, the model assumes that the cross-sectional relationships are applicable to any country.

Given these shortcomings, the underlying aim of the methodology in this report is to rely on the strength of the original USAID DemDiv model, i.e. the clear relationship it establishes between outcomes and impacts (typically one of the most contested steps in modelling), while modelling sectoral investment options that are of interest and relevance to the GoU.

In order to model the sectoral investment options, the modified DemDiv model embeds one of the most common empirical costing models used in assessing the resource requirements needed in order to obtain specific development objectives – the unit-cost approach, also known as the input-outcome elasticities approach. The most common application of the approach divides relevant government expenditure by a quantified outcome indicator. An example of this would be an earlier study that divides the current expenditure on education by the enrolled population in a specific year in order to obtain the unit-cost of primary school education. The resulting unit-cost could then be used to estimate the cost of reaching a specified projected target population. A similar study was adopted in relation to water and sanitation, yet the methodology was modified to include capital and recurrent expenditure. Similar approaches were used in the areas of biodiversity, energy, telecommunications, transportation, water and sanitation. A variation of this approach would include simple descriptive models that provide linkages between a specific investment level and specific target variables such as GDP growth.

Nevertheless, while the unit-cost approach does offer attractive options to assess resource requirements, critiques need to be taken into consideration. These include the critique by Schmidt-Traub (2015), who states that while such simple models can easily be applied to many countries, the simple projection of current expenditure requirements into the future does not account for the required changes in the composition of investment as a result of new interventions, nor does the approach account for the marginal costs and thus higher total costs associated with hard-to-reach/unserved populations. Furthermore, most unit-cost methodologies are unable to support practical policy decisions, inform vital policy trade-offs and identify complementarities due to a lack of sufficient detail. This also prohibits the estimation of the impacts of cross-sectoral synergies as well as other economy-wide effects of investment.

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5 Delamonica et al., 2001
6 Hutton & Varughese, 2016
7 CBD 2012a, 2012b; (World Bank, 2013)
8 Bhattacharya et al. 2012; Faye et al. 2011; Foster and Briceno-Garmendia 2010
programmes. Thus, while the methodology may be of use in providing a rough estimation of investment needs, a more detailed and/or integrated model is needed to guide programme implementation.

Schmidt-Traub (2015) furthermore critiques various other development goal assessment methodologies. While he emphasizes that the incremental-capital-output-ratio models suffer similar challenges as the unit-cost methodology, he acknowledges that intervention-based needs assessment tools are capable of providing a structured and transparent methodology for quantifying resource requirements at a policy-relevant level of disaggregation. Nevertheless, the tools also have their limitations as they are commonly unable to identify and assess cross-sectoral synergies.

Methodologies that are able to do so include (i) engineering system models that are extensions of the intervention-based tools that provide detailed sectoral representation and can be integrated into dynamic equilibrium models (e.g. MESSAGE, MARKAL, TIMER), and (ii) complex Computable General Equilibrium (CGE) models that can explicitly incorporate development goal production functions into its models. One of which includes the World Bank’s Maquette for MDG Simulations (MAMS),9 which supports economy-wide assessments of cross-sectoral synergies and macroeconomic forces and allows for easy application across country datasets. CGE models are designed to illustrate an economy at equilibrium through the use of aggregate production and utility functions. Based on this, changes that allow for the measurement of investment needs for various policy options can be introduced into the model. Many CGE models, including MAMS, use restrictive Cobb-Douglas production functions in order to predict development outcomes, which allow for non-constant returns to scale and historic parameterization of data.10 Thus, the computational complexity of these models does not allow insight into the investment needs of single sectors nor does it take into account market externalities.

The methodology in this report, however, limits the analysis to constant returns to scale and restricts the opportunities for the analysis of cross-sectoral synergies. A flexible and dynamic approach that assesses cross-sectoral interactions over long time periods can be provided by Integrated Assessment Models (IAMs). These models are abundant and cover a wide range of investment needs. Examples include DICE, PAGE, AIM, IMAGE and MESSAGE.11 Unfortunately, however, such models do not support the inclusion of goal-based budgeting and thus cannot identify and apply concrete estimates of the investment needed into relevant resources in order to achieve required outcomes.

As both the CGE and IAM models are based on complex methodologies that require considerable expertise, the report’s methodology is rooted in conclusions provided by Schmidt-Traub (2015) and Bourguignon et al. (2008), which underline the need for multiple complementary models and approaches. The methodology in this report thus builds on the given tools in order to adopt a policy production function, which enables the modelling of variable own- and cross-elasticities. The cross-sectoral estimations approach follows the integrated macroeconomic model created by Agénor et al. (2005).12 This approach not only employs the cross-sectional estimation in order to focus on long-run relationships between variables, but also utilizes the most common practice for doing so – the translog production function. While this allows for the variation of unit-costs and the estimation of cross-sectoral synergies, it also allows for the use of readily available fiscal data and development outcomes derived from existing household surveys. Even though the methodology is simple and uses an Ordinary Least Squares (OLS) estimation approach, it can be incorporated into more complex macroeconomic models (e.g. Agénor et al.’s integrated macroeconomic model (2005) or CGE models) as well as the original USAID DemDiv Model described above.

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9 (Bourguignon, Diaz-Bonilla, & Lofgren, 2008); (Lofgren & Diaz-Bonilla, 2010); (Lofgren, Cicowiez, & Diaz-Bonilla, 2013)
10 (Lofgren and Diaz-Bonilla, 2008)
11 DICE (Nordhaus 2008), PAGE (Hope 2006), AIM (Matsuoka et al. 2001), IMAGE (PBL 2015) and MESSAGE (Messner and Strubegger 1995).
12 (Agénor, Bayraktar, Moreira, & Aynaoui, 2005)
APPENDIX III
Methodology: Modelling Basic Indicators through Translog Regressions

As mentioned previously, the underlying aim of the methodology in this report is to rely on the strength of the original USAID DemDiv model, i.e. the clear relationship it establishes between outcomes and impacts (typically one of the most contested steps in modelling), while modelling sectoral investment options that are of interest and relevance to the GoU. Thereby the model informs policy makers on the potential benefits to be reaped from the demographic dividend. To do so, the chosen approach first models the impact that per capita sectoral expenditure had on a set of key indicators: modern contraceptive prevalence rate (CPR), mean years of schooling by gender, school life expectancy by gender, and under-five and infant mortality rates using a translog regression. These key indicators were informed by the five dividends as well as the preconditions outlined in the sections above. They are important to analyse as they are key drivers of lowering fertility as well as boosting Uganda’s health and social outcome. The resulting impacts, categorised as basic inputs/intermediate outcomes, allowed for the projections of the total population of Uganda and consequently its GDP per capita in the modified USAID DemDiv model.

When modelling expenditure or resource requirements to achieve a development outcome, various existing methodologies can be used. The study at hand chose to use translog regression specifications, rather than single-sector unit-cost and multisectoral Cobb-Douglas approaches to model outcomes based on expenditures. This improves the costing approach in several ways. First, it allows the inclusion of multiple fiscal inputs (per capita expenditure by sector) as well as their interaction terms. Secondly, it pre-empts two critical traps into which single-sector unit-cost approaches fall:

i) Over-estimating costs by ignoring policy synergies
ii) Under-estimating costs by ignoring non-linear relationships, especially that of diminishing marginal returns.

The translog approach overcomes both these limitations and can therefore model not only total cost more accurately, but also unlock the identification of synergy-producing input-outcome elasticities among sectors. These synergies demonstrate the fact that investments in sectors such as health and education interact with each other through a robust system of feedback loops, which allow for effects that are jointly significant for the resulting key indicators.

For country $i$ during time period $t$, a set of generic expenditure sectors $X_1, X_2, X_3$, etc., and a key indicator $Y$, the translog model takes the following form:

\[
\ln Y_{it} = \beta_0 + \beta_1 \ln X_{1it} + \beta_2 \ln X_{2it} + \beta_3 \ln X_{3it} + \ldots
\]

\[
+ \beta_{11} \ln X_{1it} \times \ln X_{1it} + \beta_{12} \ln X_{1it} \times \ln X_{2it} + \beta_{13} \ln X_{1it} \times \ln X_{3it} + \ldots
\]

\[
+ \beta_{22} \ln X_{2it} \times \ln X_{2it} + \beta_{23} \ln X_{2it} \times \ln X_{3it} + \ldots
\]

\[
+ v_{it} - u_{it}
\]

Where:

- $\ln Y_{it}$ = Selected key indicators (in log form) by district – (e.g., under-5 mortality rate)
- $\ln X_{1it}$ = Spending per capita on sector 1 input – (e.g., health sector investment) by district (in log form)
- $\ln X_{2it}$ = Spending per capita on sector 2 input - (e.g., education sector investment) by district (in log form)
- $\ln X_{3it}$ = Spending per capita on sector 3 input – by district (in log form), etc.
- $v_{it}$, $u_{it}$ = error terms

13 A full methodological review of approaches, their benefits and limitations is provided in Appendix II. In addition, limitations of the method used in the report are provided in Appendix IV.
In the study at hand, the translog production function model reflects an understanding that socioeconomic growth results from a public policy production process in which the key indicators represent intermediate outcomes, and per capita spending on critical policy sectors represent the inputs. The estimation focuses on several relevant expenditure sectors, are key sectors for reaping the demographic dividend: (1) education, (2) health; (3) agriculture, (4) water and environment, and (5) social development. Each indicator model includes the most relevant expenditure categories and the appropriate interaction terms representing synergy among sectors.

In the example above, the $\beta_1$, $\beta_2$, and $\beta_3$ coefficients illustrate the estimated elasticity of a key indicator with respect to its own-sector spending. This represents the direct effect of an increase in per capita sectoral expenditure on the respective returns of a key indicator ($Y_i$). For example, an increase in the per capita education expenditure of US$500 will result in a decline of infant mortality by 0.5 deaths per 1,000 live births. Furthermore, the translog models include quadratic terms for each sector, represented by $\beta_{11}$, $\beta_{12}$, and $\beta_{13}$. These terms are included to reflect the fact that increased investment in the same sector often results in diminishing marginal returns. For example, while the first increase of US$500 in per capita education expenditure reduced infant mortality by 0.5 deaths per 1,000 live births in the example provided above, the next per capita increase of US$500 reduced infant child mortality by 0.4 deaths per 1,000 live births.

The last set of coefficients ($\beta_{12}$, $\beta_{23}$, $\beta_{13}$) represent the synergy effects of investing in multiple sectors simultaneously – meaning the extent to which one sector’s spending influences the effectiveness of another sector’s spending. For example, while an increase of US$500 in per capita education expenditure reduced infant mortality by 0.5 deaths per 1,000 live births, the simultaneous increase of per capita health expenditure by US$500 reduces infant mortality even further (0.8 deaths per 1,000 live births). In order to evaluate whether or not a cross-sectoral impact is significant, an F-test for incremental contribution is used.

Thus, for each of the selected key indicators, a model is estimated using the three terms described above. The inclusion of a specific sector or its quadratic/interaction terms, depends largely on the terms’ statistically significant explanatory power in explaining variations in the estimated outcome. If a term or a group of related terms is found to be insignificant, it implies that it does not affect the dependent variable (key indicator) of the model and thus can be excluded from the equation, thereby possibly improving the overall significance of the model.\(^{14}\)

**Data description**

The inputs used in this translog model use 2016 per capita expenditure figures derived from the World Bank BOOST Database for all 112 districts in Uganda. BOOST data provides robust district-level fiscal inputs by detailing actual and budgeted public expenditures across various policy sectors at the district level of administration. The fiscal inputs included in the analysis consisted of the per capita expenditure of the health, education, social development, agriculture, and WASH (water, sanitation, and hygiene) sectors. Using district-level BOOST data is advantageous, as districts across Uganda show a wide variation in demography, size, and degree of urbanisation. Such high levels of variation allow for robust cross-sectional modelling. The summary statistics on sectoral spending show that these expenditures all display significant standard deviations from their means signifying that the data capture fiscal inequalities across different regions of the country, allowing for large enough statistical variance and more accurate standard errors (Table A1).

\(^{14}\) The list of intermediate outcome equations used in the modified DemDiv model can be found in Appendix V.
TABLE A1. DESCRIPTIVE STATISTICS ON SECTORAL EXPENDITURE ACROSS 112 UGANDAN DISTRICTS (2015/16)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>40209.5</td>
<td>17961.7</td>
<td>12605.0</td>
<td>126868.6</td>
</tr>
<tr>
<td>Health</td>
<td>11146.2</td>
<td>5791.9</td>
<td>2639.3</td>
<td>29453.7</td>
</tr>
<tr>
<td>Water &amp; Environment</td>
<td>2710.8</td>
<td>1632.3</td>
<td>629.6</td>
<td>8857.0</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1216.2</td>
<td>777.6</td>
<td>234.3</td>
<td>6426.6</td>
</tr>
<tr>
<td>Social Development</td>
<td>247.9</td>
<td>182.2</td>
<td>56.8</td>
<td>1544.1</td>
</tr>
</tbody>
</table>

Note: The given statistics are only for domestic financing.  
Source: Authors’ own calculations.

Dependent variable (key indicator) data was derived from the 2016 Uganda Demographic and Health Survey (UDHS). This survey provides household and individual level demographic, health, education, family planning, and income data for residents throughout all areas of Uganda. All key indicators were constructed after disaggregating respondents by district and (if necessary) by gender. Aggregate, national-level indicators were constructed only as a data and methods check for each key indicator. National household surveys are usually representative at best at the regional level. However, district-level aggregations support inferences on production function relationships without necessarily identifying robust district-level indicators.

The estimated key indicators at district level are not precisely representative of the associated districts. However, they support the econometric estimation of the translog production function employed in this analysis. The high variance associated with the statistical properties of the key indicators reduces the goodness-of-fit of the estimated models, but does not preclude the estimation of statistically significant relationships between the BOOST fiscal inputs and the chosen key indicators.

**Out-of-Sample Projections**

Translog specifications for each key indicator require the calculation of spending scenarios for each year up to 2040. To this end, this study takes existing GDP growth projections (available until 2023) to estimate GDP and expenditure growth. Future GDP growth projections are taken from a 10-year moving average, resulting in approximately 6% annualised growth from 2026 and beyond. Given that GDP is an exogenous variable in the model and therefore cannot be linked to the population projections, it is assumed that the resulting economic growth rate would not be affected by a lower labour supply as Uganda exhibits an excess supply of labour in its economy.

These projected GDP figures allow for the establishment of a baseline ‘economic growth only’ scenario, where existing expenditures in each major sector grow at the same rate as GDP (see Box). The model forecasts intermediate outcomes for each key indicator using the projected sectoral expenditure and the coefficient estimates from the translog regressions for each year up to 2040. These forecasts are created using translog models with and without synergy terms, to illustrate the long-term impacts of sectoral synergies.
Aside from the Base Scenario, the model implements two policy scenarios. Both of these include an increase in their sectoral expenditure by specified 2080 targets yet differ in terms of whether or not cross-sectoral synergies are exploited (see Box). The 2080 expenditure targets can be defined as percentage increases in final sector expenditure relative to the baseline expenditure scenario (e.g. a 50% increase in education expenditure as a share of GDP by 2080 relative to the baseline). The identification of the specific 2080 expenditure targets was based on several statistical iterations. While the maximum increase in sectoral expenditure as a share of GDP was capped at 50%, it was found that the optimal outcomes were achieved with the following expenditure targets: 50% increase in health and education expenditures as a share of GDP, 20% in social development spending, 30% in water and environment spending, and 40% in agriculture spending. Obtaining expenditure targets below these levels by 2080 would lead to sub-optimal results, while achieving targets above the provided levels could potentially lead to even better outcomes. Based on these targets, individual year expenditure values were interpolated to reflect smooth growth to this spending level. The policy scenarios determine the inputs used in the translog regression to obtain the intermediate outcomes (yearly key indicator projections to 2040), allowing for the direct calculation of endogenous outcomes such as life expectancy and total fertility rate. Subsequently, these outcomes were used to estimate the endogenous impact on the total population of Uganda, which in turn allowed for the computation of GDP per capita (Figure A2).

<table>
<thead>
<tr>
<th>THE THREE SCENARIOS OF THE DEMDIV MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Scenario</strong></td>
</tr>
<tr>
<td>Constant growth and no synergies</td>
</tr>
<tr>
<td>This scenario reflects a no change scenario. The GoU continues to invest in its sectors and implement policies as it has done so far. This implies that sectoral expenditure is projected to grow at the rate of GDP for the next 35 years, while no cross-sectoral synergies are achieved.</td>
</tr>
</tbody>
</table>

| **Policy Scenario 1**                  |
| Exponential growth and no synergies    |
| Under this scenario, the analysis identified the optimal growth rates by which sectoral investments need to grow in order to maximize the demographic dividend. It was found that the GoU would need to increase sectoral expenditure by the following: 50% increase in educational expenditure, 50% increase in health expenditure, 20% increase in social development expenditure, 40% increase in agriculture expenditure, and 30% increase in expenditures on water and the environment by 2040. Moreover, this scenario does not take advantage of cross-sectoral synergies. |

| **Policy Scenario 2**                  |
| Exponential growth and synergies       |
| Under this scenario, the GoU not only increases its sectoral expenditure by the amounts described in Scenario 1, it also diversifies its sectoral investment portfolio in order to create cross-sectoral synergies. |

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15 2080 was used as the target year as this seemed to be a realistic timeframe over which the Ugandan government could adjust its spending. Furthermore, 2080 marks the year in which Uganda’s dependency ratio starts to increase again, highlighting the fact that the window of opportunity to reap benefits from the demographic dividend is closing. However, an alternative analysis based on 2040 as the target year, and thus in line with Uganda’s Vision 2040, is presented in Appendix VI.

16 The increase in expenditures were capped at 50% as this is already a significant increase from the base year given Uganda’s fiscal space constraints.

17 It is important to note that the modelled increase in national expenditure is completely absorbed at the subnational level.

18 The subsequent estimations of the translog functions can be found in Annex IV.
FIGURE A2. ILLUSTRATION SUMMARIZING THE MAIN INPUTS, OUTCOMES AND IMPACTS OF THE METHODOLOGY

INPUTS
- Per capita health expenditure’s
- Per capita education expenditure’s
- Per capita agriculture expenditure’s
- Per capita WASH expenditure’s
- Per capita social development expenditure’s

EFFECT ON
- Under-five mortality
- Infant mortality
- Expected years of schooling
- Mean years of schooling
- Modern contraceptive prevalence rate

IMPACTS
- Projected total population
- Projected GDP per capita

OUTCOMES
- Total fertility rate
- Female life expectancy

BASIC INPUTS (INTERMEDIATE OUTCOMES)
- Under-five mortality
- Infant mortality
- Expected years of schooling
- Mean years of schooling
- Modern contraceptive prevalence rate

USAID DemDiv Model
APPENDIX IV
Limitations

Future modelling exercises could be even more successful in modelling outcomes conditional on the availability of more and richer data. Moreover, the modified model has several of the same limitations identified by the original USAID DemDiv model.

First, the statistical relationships that underlie the economic model were not modified. Thus, the original parameters presented by the USAID DemDiv Model hold. These were based on international cross-sectional data and were assumed to not change over time.

Secondly, interlinkages between the economy and population growth were not incorporated (e.g. childcare effects on labour supply, the role of land in production as well as population-induced technological progress).

Thirdly, more sophisticated dynamics cannot be captured as the model at hand is a single-sector model. It does not account for shifts in production, demand or the supply of labour among multiple sectors in the economy. Lastly, the model is a partial equilibrium model and therefore does not model labour and capital markets as would a computable general equilibrium model.
APPENDIX V
List of outcome equations used in the modified DemDiv model

i) Female school life expectancy
The expected years of schooling were modelled for two specific scenarios – one which did not include
cross-sectoral synergies (simple) and one which did (complex). Thus, the female school life expectancy
for time period $t$ is modelled as a function of sectoral investments at time period $t$:

**Simple Female school life expectancy**$_t$ = -43.43 + LN(education pc)$^*$12.62 + 0.5 $^*$
LN(education pc)$^{2*}$ -1.15 + LN(agriculture pc)$^*$ -3.9 + 0.5 $^*$
LN(agriculture pc)$^{2*}$ 0.56 + LN(health pc)$^*$ -4.47 + 0.5 $^*$ LN(health pc)$^{2*}$ +
0.47 + LN(watenv pc)$^*$ 3.11 + 0.5 $^*$ LN(watenv pc)$^{2*}$ -0.44

**Complex Female school life expectancy**$_t$ = -18.41 + LN(education pc)$^*$ 7.29 + 0.5 $^*$
LN(education pc)$^{2*}$ -1.10 + LN(agriculture pc)$^*$ -2.55 + 0.5 $^*$
LN(agriculture pc)$^{2*}$ 0.12 + LN(health pc)$^*$ -0.29 + 0.5 $^*$ LN(health pc)$^{2*}$ +
0.19 + LN(watenv pc)$^*$ -2.21 + 0.5 $^*$ LN(watenv pc)$^{2*}$ -0.56 + 0.5 $^*$
(LN(agriculture pc)$^*$LN(socialdev pc))$^*$ 0.67 + 0.5$^*$
(LN(education pc)$^*$LN(watenv pc))$^*$ 1.21 + 0.5 $^*$
(LN(health pc)$^*$LN(socialdev pc))$^*$ -0.53

Where:

education pc = sectoral expenditure on education per capita
agriculture pc = sectoral expenditure on agriculture per capita
health pc = sectoral expenditure on health per capita
watenv pc = sectoral expenditure on water and the environment per capita
socialdev pc = sectoral expenditure on social development per capita

ii) Percentage of women married or in a union
The percentage of women married or in a union is modelled as a function of female education:

$\ln \text{(Percentage of Women Married)} = -0.332 \times \ln(\text{Female School Life Expectancy})$

iii) Total Fertility Rate (TFR)
TFR is obtained using the following formula:

$TFR_t = C_m \times C_i \times C_a \times C_s \times C_c \times TF$

Where:

$C_m =$ the percentage of women of reproductive age who are married or in union
$C_i =$ insusceptibility index = 20.0 / (18.5 + Period of postpartum insusceptibility in months)
$C_a =$ Index of induced abortion (currently omitted from the model)
$C_s =$ Index of sterility = (7.63 – 0.11*Percent sterile)/7.3
$C_c =$ index of contraception = 1-1.08*(prevm*effectivenessm) + (prevt*effectivenessst)19
$TF =$ Index of total fertility (like the induced abortion, this is not directly used as an input)

iv) Percentage of births at risk
The model projects the % of births at high risk with the following equation:

The percent of births at high risk = 7.28 $\times$ TFR

19 Prevm stands for the prevalence of modern methods and effectivenessm is an effectiveness factor defined by the user (default is 95% for modern methods and 5% for traditional methods)
v) **Maternal mortality**

\[
\text{Maternal mortality}_t = \frac{\text{Maternal mortality rate}_{t-1}}{\exp(4.7651 \times \text{Percent of births at any risk}_{t-1})} \times \exp(4.7651 \times \text{Percentage of births at any risk}_t)
\]

vi) **Infant mortality**

Infant mortality was modelled for two specific scenarios – one which did not include cross-sectoral synergies (simple) and one which did (complex). Thus, infant mortality for time period \( t \) is modelled as a function of sectoral investments at time period \( t \):

**Simple Infant mortality\( t \):**

\[
16.53 + \ln(\text{health}_{pc}) \times -5.33 + 0.5 \times \ln(\text{health}_{pc})^2 \times 0.54 + \ln(\text{agriculture}_{pc}) \times 3.61 + 0.5 \times \ln(\text{agriculture}_{pc})^2 \times -0.48
\]

**Complex Infant mortality\( t \):**

\[
25.74 + \ln(\text{health}_{pc}) \times -9.64 + 0.5 \times \ln(\text{health}_{pc})^2 \times 0.47 + \ln(\text{agriculture}_{pc}) \times 6.79 + 0.5 \times \ln(\text{agriculture}_{pc})^2 \times -0.48 + 0.5 \times (\ln(\text{education}_{pc}) \times \ln(\text{health}_{pc})) \times 0.94 + 0.5 \times (\ln(\text{water}_{pc}) \times \ln(\text{education}_{pc})) \times -1.13 + 0.5 \times (\ln(\text{agriculture}_{pc}) \times \ln(\text{water}_{pc})) \times 1.68
\]

Where:
- \( \text{education}_{pc} \) = sectoral expenditure on education per capita
- \( \text{agriculture}_{pc} \) = sectoral expenditure on agriculture per capita
- \( \text{health}_{pc} \) = sectoral expenditure on health per capita
- \( \text{water}_{pc} \) = sectoral expenditure on water and the environment per capita

vii) **Under-five mortality**

Under-five mortality was modelled for two specific scenarios – one which did not include cross-sectoral synergies (simple) and one which did (complex). Thus, under-five mortality for time period \( t \) is modelled as a function of sectoral investments at time period \( t \):

**Simple under-five mortality:**

\[
47.52 + \ln(\text{health}_{pc}) \times 0.26 + 0.5 \times \ln(\text{health}_{pc})^2 \times -0.05 + \ln(\text{agriculture}_{pc}) \times 2.39 + 0.5 \times \ln(\text{agriculture}_{pc})^2 \times -0.31 + \ln(\text{education}_{pc}) \times -9.86 + 0.5 \times \ln(\text{education}_{pc})^2 \times 0.92
\]

**Complex under-five mortality:**

\[
10.06 + \ln(\text{health}_{pc}) \times -3.30 + 0.5 \times \ln(\text{health}_{pc})^2 \times 0.32 + \ln(\text{agriculture}_{pc}) \times 2.91 + 0.5 \times \ln(\text{agriculture}_{pc})^2 \times -0.36 + 0.5 \times (\ln(\text{water}_{pc}) \times \ln(\text{socialdev}_{pc})) \times 1.08 + 0.5 \times (\ln(\text{education}_{pc}) \times \ln(\text{socialdev}_{pc})) \times 1.07 + 0.5 \times (\ln(\text{water}_{pc}) \times \ln(\text{socialdev}_{pc})) \times -0.86
\]

Where:
- \( \text{education}_{pc} \) = sectoral expenditure on education per capita
- \( \text{agriculture}_{pc} \) = sectoral expenditure on agriculture per capita
- \( \text{health}_{pc} \) = sectoral expenditure on health per capita
- \( \text{water}_{pc} \) = sectoral expenditure on water and the environment per capita
- \( \text{socialdev}_{pc} \) = sectoral expenditure on social development per capita
viii) Female life expectancy
Life expectancy for females is derived from the under-five mortality rate:

\[
\ln(\text{Female Life Expectancy}) = \begin{cases} 
-0.59 \times \ln(\text{Under-five Mortality Rate}) & \text{if the under-five mortality rate} < 50.9 \\
-0.287 \times \ln(\text{Under-five Mortality Rate}) & \text{if the under-five mortality rate} > 50.9
\end{cases}
\]

ix) Contraceptive effect modern
The modern contraceptive prevalence rate (CPRm) was modelled for two specific scenarios – one which did not include cross-sectoral synergies (simple) and one which did (complex). Thus, CPRm for time period \( t \) is modelled as a function of sectoral investments at time period \( t \).

**Simple modern Contraceptive Prevalence Rate**
\[
= 26.76 + \ln(\text{education}_pc) * 9.31 + 0.5 * \ln(\text{education}_pc)^2 * -0.81 + \ln(\text{health}_pc) * -0.83 + 0.5 * \ln(\text{health}_pc)^2 * 0.08 + \ln(\text{agriculture}_pc) * -4.99 + 0.5 * \ln(\text{agriculture}_pc)^2 * 0.67
\]

**Complex modern Contraceptive Prevalence Rate**
\[
= 11.69 + \ln(\text{health}_pc) * -5.47 + 0.5 * \ln(\text{health}_pc)^2 * -0.26 + \ln(\text{agriculture}_pc) * -2.62 + 0.5 * \ln(\text{agriculture}_pc)^2 * 0.44 + \ln(\text{education}_pc) * 9.07 + 0.5 * \ln(\text{education}_pc)^2 * -1.80 + 0.5 * (\ln(\text{education}_pc) * \ln(\text{health}_pc)) * 1.93 + 0.5 * (\ln(\text{education}_pc) * \ln(\text{health}_pc)) + 1.30 + 0.5 * (\ln(\text{education}_pc) * \ln(\text{water}_pc)) * 1.51
\]

Where:
- \( \text{education}_pc \) = sectoral expenditure on education per capita
- \( \text{agriculture}_pc \) = sectoral expenditure on agriculture per capita
- \( \text{health}_pc \) = sectoral expenditure on health per capita
- \( \text{water}_pc \) = sectoral expenditure on water and the environment per capita

x) Contraceptive effect traditional
The traditional contraceptive prevalence rate was based on the modern contraceptive prevalence rate calculation. If the sum of the modern contraceptive prevalence rate and the traditional contraceptive prevalence rate were more than 100%, then the traditional contraceptive prevalence rate in the base year (2015) was subtracted from the modern contraceptive prevalence rates. Otherwise, the modified DemDiv model assumes a rate equal to that reported in the base year (2015).
APPENDIX VI

Findings and lessons from literature relating to expenditure targets

Fiscal space for social sector expenditures in Uganda has been tight, especially since the country has prioritized investing in infrastructure spending. In fact, social sector expenditures have been low (approximately 3.4% of GDP) even by regional standards, though stable. Overall, the education sector has accounted for the majority of social sector expenditures (60%), while spending on water and the environment and social development has been particularly low (0.28% and 0.07% of GDP in 2018). A recent study by UNICEF illustrated Uganda’s difficulty in mobilizing domestic revenue has constrained some sectors more than others – especially education and health. For Uganda to reap the demographic dividend, fiscal space needs to be created in order to increase expenditure in the social sectors (UNICEF & ECORYS, 2018).

Examples of countries that have attained the demographic dividend show how important investments in the social sectors are. For example, India’s first demographic dividend started in 1995. By 2005, its expenditure on education equalled 2.61% of GDP, while 1.23% was invested in health and 1.65% in other social services. Overall, this amounted to a total of 5.5% of GDP on its social sector. This increased to 6.63% by 2011, with approximately 3% on education, 1.27% on health and 2.38% on others (Ladusingh & Narayana, 2011). Furthermore, the Asian Tigers (South Korea, Singapore, Hong Kong and Thailand), which started their demographic dividends in the early to mid-1970s, had educational expenditures of, on average, 2.8% of GDP. By country, this equated to 3.4% of GDP in South Korea, 3.1% in Singapore, and 2.4% in Hong Kong and Thailand (World Bank, 2019). Additionally, South Africa and Botswana are currently in the midst of their demographic transition with expenditure on education equalling 6.1% of GDP in South Africa and more than 9% in Botswana, while expenditure on health is to 4.4% and 3.1%, respectively (World Bank, 2019). In 2019, Uganda spent just 1.7% of GDP on education and 0.8% on health.

In recent times, the GoU has shifted its balance of spending to favour infrastructure investment over the social sectors. However, this expenditure shift to economic and productive sectors has yet to bear fruit. A study by Das and Kar (2016) on India has concluded that expenditure on education has a direct effect on technical knowledge, while health-related expenditure affects the country’s productive capacity even for low-skilled labour. Furthermore, while countries in East Asia have placed a high value on education expenditures, other countries, such as the United States, have focused their attention on increasing health care (Lee & Mason, 2006). This suggests that Uganda needs to place more of its investments in its social sectors. Consequently, the analysis in this paper has set the education and health expenditure target growth rate at 50%. By 2080, Uganda would have increased government education expenditure to 2.6% – in line with that of the Asian Tigers – while health expenditure would rise to 1.27%, close to the level in India.

In the area of social development, the increase in per capita GDP is a major step in the fight against poverty and inequality. According to Dramani (2018), sub-Saharan Africa, along with parts of South East Asia, are the least wealth generating regions in the world. Although many countries in sub-Saharan Africa have experienced high economic growth rates over the recent past, the elimination of poverty and the reduction of inequality remains the most important priority for the region. In order to achieve this, literature has pointed towards the immediate strengthening of human capital, while simultaneously creating decent and sustainable jobs for Africa’s youth. Furthermore, the Addis Ababa Action Agenda presents a new social compact that requires Uganda to commit to the delivery of social protection systems for all. This would include the setting of national spending targets for quality investments in the five dividend sectors mentioned throughout the analysis. At present, developing countries spend, on average, 1% to 2% of GDP on this sector while Uganda spends just 0.07%. The current level of expenditure is therefore needs to be increased by 30% in order to attain the minimum expenditure of other developing countries (1%) by 2080.
With respect to the agriculture sector, Uganda has been experiencing low productivity growth which has been an obstacle to the economy flourishing. Such low productivity reflects the underlying structure of the economy, which is characterized by a lack of medium- and large-scale enterprises and agricultural modernization (UNICEF & ECORYS, 2018). As investment in education is forecasted to improve the human capital available to Uganda, it is expected that the agriculture sector will also benefit. The expenditure growth rate target for the agricultural sector was thereby set to just under that of health and education (40%). This was also the level at which optimal results were attained for Uganda in the long term.

Lastly, sectoral investments in the water, sanitation and health sector are important as they are essential to human development and are considered a basic human right. In Africa, providing access to clean water, good hygiene practices and basic toilets is still a key challenge. While still low on the political agenda of some African countries, increasing evidence has shown the positive effects such investments can have on a population’s health, safety and dignity. The improvement of these basic human rights is also advocated for in the SDGs. Targets 6.1 and 6.2 call for universal access to water as well as the elimination of open defecation, respectively. In countries that have gathered reliable data, WASH expenditure is seen to constitute between 0.7% and 3.7% of GDP. This includes Zambia (0.7%), Kenya (0.8%), Mali (1.3%), Lesotho (2.1%), South Africa (2.6%) and Ghana (3.7%). It should be noted, however, that these amounts are composed of household expenditures, government expenditures, external sources and repayable financing. Thus, in South Africa, government expenditure accounted for less than 30% of the total WASH expenditure, equating to a total share of GDP of less than 0.8%. In Ghana, government expenditure accounts for approximately 5% of total WASH expenditure (roughly 1.86% of GDP), while in Zambia this equates to 20% of total WASH expenditure (0.15% of GDP) (CABRI, 2018).

At present, GoU expenditure on WASH is above that of Zambia, but twice as low as that in South Africa. Thus, given the fiscal constraints the GoU is facing and underlining the fact that an increase of expenditure in health and education are of more importance at the moment, the analysis at hand has set the expenditure target growth rate for the WASH sector to 30%. This will allow Uganda to attain a level of spending equivalent to 0.4% in 2080. However, it must also be stressed that if additional fiscal space were to be found, Uganda should increase this target growth rate.
APPENDIX VII

Figures for Sectoral Expenditure as a share of GDP under Base Scenario and Scenario 2

Table A2 below shows the increase in sectoral expenditure as a share of GDP under the Base Scenario and Scenario 2.

The Baseline Scenario linearly projected sectoral expenditure as a share of GDP based on historical trends (i.e. the last five years). The growth scenario (Scenario 2) depends on the projected expenditure as a share of GDP of the base scenario and the assumed target growth rates. Thus, it takes the 2080 projected sectoral expenditure as a share of GDP amount under the Baseline Scenario and multiplies it times (1+ target growth rates) to get the expected sectoral expenditure in 2080 under Scenario 2.

The target growth rates (as stipulated in the report) were assumed to be the following: health 50%, education 50%, social development 20%, WASH 30%, and agriculture 40%. The growth targets refer to the difference in the projected shares of sectoral expenditure as a % of GDP.

### TABLE A2. INCREASE IN SECTORAL EXPENDITURE AS A SHARE OF GDP UNDER THE BASE SCENARIO AND SCENARIO 2

<table>
<thead>
<tr>
<th>Year</th>
<th>Health</th>
<th>Education</th>
<th>Social Development</th>
<th>WASH</th>
<th>Agriculture</th>
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<td>0.00%</td>
<td>0.83%</td>
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<tr>
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<tr>
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<td>0.83%</td>
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<td>1.78%</td>
<td>0.00%</td>
</tr>
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<td>0.83%</td>
<td>0.83%</td>
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<tr>
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AN ASSESSMENT OF THE IMPACT OF MULTI-SECTORAL APPROACHES
<table>
<thead>
<tr>
<th>Year</th>
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<th>Education</th>
<th>Social Development</th>
<th>WASH</th>
<th>Agriculture</th>
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Note: Figures in orange are derived by subtracting the Base Scenario growth rate of sectoral expenditure in 2080 from the Scenario 2 growth rate in 2080 to arrive at the assumed sectoral growth rates in 2080.

Source: Calculations based on authors’ own projections.

Change from 2019

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