Long-Term Growth Model (LTGM)
MTI Forum Learning Module

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30 April 2018

www.worldbank.org/LTGM (external URL) or http://LTGM (internal FURL)

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Model Overview

• Countries want to grow at high rates
  • What growth rates are feasible? What would it take to achieve these goals?

• A simple model to analyze long-term growth
  • Based on celebrated Solow-Swan Model: savings and investment key
  • Also TFP, human capital, demographics, labor participation, FDI & external debt

• Toolkit for use by country economists/policymakers in many countries
  • Spreadsheet-based for simplicity.
  • No macros; transparent, flexible & easy-to-learn
  • Continuously adding new features – comments always welcome

• New in LTGM v4 – implications of growth for poverty
Objectives of the Model

• Help policy makers in finding answers to 3 important policy questions:
  • Model 1: How much growth from a given investment profile?
  • Model 2: How much investment is needed to achieve a given growth profile?
  • Model 3: How much growth from a given savings profile?
    • Requires assumptions on debt or current account balance

• Allow policy makers ample flexibility
  • Scenario analysis using many other variables: Productivity, Human Capital, Demographics, External sector
  • New Extension of Growth → Poverty

• For long-run scenario analysis -- not short-run analysis or forecasting
Some examples of previous work

Used in CEMs, SCDs and other growth analysis all over the world (20+ countries):

- **Sub-Saharan Africa**: Cameroon (CEM), Zambia (SCD), Guinea (SCD), Seychelles (SCD), Ghana (SCD), Zimbabwe, Malawi, Cape Verde, South Africa
- **South Asia**: Bangladesh, Nepal (CEM), Sri Lanka (CEM)
- **Latin America & Caribbean**: Brazil, Peru, Panama, El Salvador, Guatemala, Honduras
- **East Asia & Pacific**: Philippines, Malaysia
- **Europe and Central Asia**: Georgia (SCD), Armenia (SCD), Kyrgyz Republic (SCD)
- **MENA**: Egypt (CEM)

- **Eg Cameroon CEM** – goal to boost growth to 8% become an UMI country by 2035.
  - Planned investment insufficient without higher TFP growth → reforms needed

- **Honduras, Panama, Peru, Zambia, Bangladesh** – Training for govt officials on how to use LTGM
Outline of the Rest of the Talk

Part A: Overview of the LTGM

1. Explanation of how the growth model works
   • Equations, parameters, assumptions and drivers of growth

2. Poverty and other extensions

Part B: Hands-on demonstration and tutorial

• Examples: investment -> growth, poverty, growth target, savings/debt constraints
• Simulations for your country

Comments/Questions/Suggestions
1. The Growth Model
Three Building Blocks of the Model

1. Production Function

\[ Y_t(GDP) = A_t K_t^{1-\beta} (h_t L_t)\beta \]

2. Capital Accumulation

\[ K_{t+1} = (1 - \delta) K_t + I_t \]

3. Demographics and Labor Market:

\[ y_t^{PC}(GDP \text{ per capita}) = \frac{Y_t}{N_t} = \frac{Y_t}{L_t} \frac{L_t}{W_t} \frac{W_t}{N_t} = A_t K_t^{1-\beta} h_t^{\beta} \rho_t \omega_t \]

\( W_t \): working-age pop; \( N_t \): total population; \( \rho_t \): participation rate; \( \omega_t \): working-age-pop. to pop. ratio \( A_t \): TFP; \( K_t \): capital; \( h_t \): human capital per worker; \( L_t \): workers)
Growth Drivers

\[ g_{y,t+1} \approx g_{A,t+1} + \beta (g_{h,t+1} + g_{\omega,t+1} + g_{N,t+1} + g_{\rho,t+1}) + \left[ \frac{1-\beta}{K_t/Y_t} \right] \frac{I_t}{Y_t} - (1-\beta)\delta \]

- [GDP Growth]  [TFP]  [Human Cap]  [Demographics]  [Participation]  MPK=1/mICOR  [Investment]

- **Common policy message:** investment-led growth [by itself] is not sustainable in long run
  - ↑ K/Y reduces the effectiveness of investment over time
  - Leads to an increase in the \( mICOR_t = \frac{1}{1-\beta} \frac{K_t}{Y_t} \) (ppt increase I/Y needed for extra 1% growth)
  - Needs to be accompanied by other sources (e.g., human capital, TFP, participation)
External Sector (how to fund investment?)

1. Current Account Balance (CAB):
   \[ I_t/Y_t = S_t/Y_t - CAB_t/Y_t \]

2. External Debt (we assume \( \Delta NFA_t \approx 0 \))
   \[ CAB_t = \Delta NFA_t - \Delta NFL_t = -(FDI_t + (D_t - D_{t-1})) \]

   Net Foreign Assets; Net Foreign Liabilities; Foreign Direct Inv.; Change Total External Debt

   \[ \Rightarrow \frac{I_t}{Y_t} = \frac{S_t}{Y_t} + \frac{FDI_t}{Y_t} + \frac{D_t}{Y_t} - \frac{D_{t-1}/Y_{t-1}}{(1 + g_{y,t}^{pc})(1 + g_{N,t})} \]

• Common policy message: need increase savings or attract FDI to fund investment plans
Saving and Investment
Average, 1980-2008

Source: Hevia & Loayza (2012)
Solving the Model - Parameters

• Can solve the model in simple spreadsheet *without macros*

• Minimal Data requirements - only need data on **three** parameters
  • Labor share ($\beta$)
  • Depreciation rate ($\delta$)
  • Initial Capital-to-Output Ratio ($\frac{K_0}{Y_0}$)

• $\uparrow \beta$, $\uparrow \delta$ and $\uparrow \frac{K_0}{Y_0}$ all make growth harder via capital accumulation

• New in LTGM v4.1 - users can choose preloaded data source & time horizon via dropdown menu – and compare in “data summary” tab
Solving the Model - required assumptions (future)

• Needed for all models:
  • Growth rate of TFP \((g_{A,t})\); Human Capital per worker \((g_{h,t})\);
  • Demographics: Population \((g_N)\) & Working-age-pop ratio \((g_\omega)\)
  • Participation rates \((g_\rho,t)\)

• Model 1: Investment share of GDP \((l_t/Y_t)\)
  • Returns the growth rate of GDP per capita (or GDP per worker)

• Model 2: Growth rate of GDP per capita \((g_{y^{PC},t+1})\)
  • Returns the investment share of GDP

• Model 3: Savings share of GDP \((S_t/Y_t)\) and CAB/Y or Ext. Debt/Y & FDI/Y
  • Returns the growth rate of GDP per capita (or GDP per worker)
2. Poverty and other Extensions
Poverty extension (part of LTGM v4)

• 2030 Goals to eliminate extreme poverty & halve poverty (at national lines)
  • But what growth rates are required? How do current growth paths affect poverty?

• Based on Log-Normal approx. of the income distribution
  • Can analyze in Excel simply using preloaded data (no microdata required)
  • Automatically produces a Growth Elasticity of Poverty (GEP) (or users can add their own)

• Can assume constant inequality or reduced inequality (income Gini)
  • Lower inequality: (i) reduces poverty directly & (ii) increases effect of growth on poverty

• “Shared prosperity premium” where income of B40 grows faster
  • Translate this into path for Gini coefficient and examines effect on poverty rates

• Caveat: the “type” of growth doesn’t impact poverty (eg which sector grows)
How poverty extension works

• Assume a constant Gini coefficient over time.

• Growth increases everyone’s income or consumption by the same percentage
  • Shifts the log distribution to the right

• Effect on poverty varies by how many people are near the poverty line
  • Larger ppt fall in poverty when poverty rate is close to 50%
  • Varies by country, poverty line & time

• In more equal countries (lower Gini coeff)
  → more compressed distribution
  → more ppl near poverty line
  → larger effect of growth on poverty

Recent extensions

1. **Public Capital Extension** (LTGM-PC, Devadas & Pennings 2018)
   - Split total capital stock into private and public (e.g., infrastructure)
     → Effect of public inv. larger if (i) relatively scarcer (ii) essential infrastructure.
   - Allow for public capital to be of poor quality (e.g., unpaved/potholed roads)
     → New index on public investment efficiency (e.g., electricity & water losses)
     → For many LI countries, increasing efficiency can have large effect on growth

2. **TFP Extension** (Kim & Loayza 2018)
   - LTGM plug-in that maps changes in innovation, education, market efficiency, infrastructure and institutions → path for TFP growth (based on cross-country regressions)

3. **Work in Progress**
   - Natural Resource Extension – useful for commodity exporting countries.
   - Advanced Sectoral Growth Tool – looks at sectors and structural transformation
Part B: Spreadsheet Tutorial

Download LTGM v4.1 spreadsheet from [www.worldbank.org/LTGM](http://www.worldbank.org/LTGM)
Spreadsheet Structure

• **InputDataA_GeneralAssumptions** – Assumptions/parameters that affect all simulations (country, start year, TFP growth, K/Y, poverty etc)

• **GraphsA** plots all general assumptions in **InputDataA**.

• **InputDataB_ModelSpecAssumptions** – Assumptions for specific models
  • Model 1: Investment share of GDP → GDP Growth
  • Model 2: Growth rate → Investment share of GDP
  • Model 3: Savings share of GDP → GDP Growth

• **GraphsB** plots results of each model (and assumptions from **InputDataB**).

• Model 1/1s/2/2s/3/3s -- see the formulas here (no macros)

• **DataSummary** – overview of historical data and parameters from different sources
(i). Model 1 Investment → Growth (ASSUMPTIONS)

InputdataA: Choose general parameters
- Country=Zambia
- Initial year=2017
- Labor share ($\beta$) = 61.8%
- Depreciation rate ($\delta$) = 4.9%
- Initial ($K_0/Y_0$) = 2.42
- 0.006 (0.06%) Human capital growth
- 0.01 (1%) TFP growth – initial & target

InputdataB: Model 1 specific assumptions
- 0.31 Initial investment (31% GDP)
- Baseline – no change (target=initial)
- Scenario – fall to 0.2 by 2020 (set as target)

GraphsB - check get this graph for Investment →
(i) Model 1 Investment $\rightarrow$ Growth (RESULTS)

**GraphsB - check get this graph for Growth $\rightarrow$**

**Model 1: (baseline)**
- Final value in 2050 should be 2.7%
  (Look in endogenous variables)

**Model 1s: (scenario)**
- Final value in 2050 should be 2.5%
  (Look in endogenous variables)

- Why does growth fall in baseline & rise in the scenario (hint: look at changing K/Y & ICOR)?
(ii) Model 1 Poverty Extension

Start with Model 1 simulation in (i)

InputdataA: Choose general parameters

• Initial poverty rate at 0.644 (default)
• Poverty line of $1.9/day (PovCalNet - default)
• Set the Growth Elasticity of Poverty (GEP) on Automatic (the default)
• Initial Gini coefficient of income 0.556
  • Constant (initial= target)

GraphsB - check get this poverty →

By 2049 Results (Model 1/1s sheet bottom)

• Poverty: 30.4% (baseline) vs 38.1% (scenario)
(iii) Model 1 Poverty target with ↓ inequality

**Goal:** halve poverty 60% → 30% by 2030

Make sure the Gini coefficient option is chosen

Start with Model 1 simulation in (ii)
- *InputdataB* set scenario investment=0.31
- scenario= baseline (=constant 0.31)

*InputdataA*: parameters for poverty
- Initial poverty rate at 0.6
- Scenario Gini target of 0.42 by 2030

*By 2030 Results (Model 1/1s sheet bottom)*
- Poverty: 44.7% (*baseline*) vs 29.4% (*scenario*)

*GraphsB - check get this graph for poverty* →
(iv) Model 2: Growth Target → Investment

Start with Model 1 simulation in (iii)

InputdataA parameters for TFP growth
• Initial TFP growth of 0.01 (1% TFP growth)
• Baseline: 0.01 (1%) constant (initial = target)
• Scenario: 0.02 (2%) TFP growth target by 2020

InputdataB: Model 2 specific assumptions
• Select GDP growth target from dropdown menu
• Initial = 0.065 (6.5% GDP growth (not per capita))
• Baseline & Scenario – no change (target=initial)

GraphsB - check get this graph for investment →

By 2049: Required investment (Model 2/2s sheet)
• 58.7% (baseline) vs 21.2% (scenario)
(v). Model 3 Savings + Debt → Growth (ASSUMPTIONS)

- Start with Model 2 simulation in (iv)
- InputdataA: 1% constant TFP growth
  - Initial=Baseline=Scenario 0.01 Constant

InputdataA: External Balance (previously didn’t matter)
- FDI: initial & target 6% GDP (baseline & scenario)
- External Debt Constraint (dropdown menu)
- Initial external debt balance to 0.5 (50% GDP)
- Baseline: 0.6 external debt/GDP by 2030 (60% GDP)
- Scenario: 0.4 external debt/GDP by 2030 (40% GDP)
- Initial CAB/Y=-0.06

InputdataB: Model 3 Savings: 25% GDP constant
- Initial=Baseline=Scenario 0.25 Constant

GraphsA - check get this graph (debt red/blue only) →
(v). Model 3 Savings + Debt → Growth (RESULTS)

*GraphsB - check savings is constant 25%*

*GraphsB - check get GDP Growth →*

*(Headline GDP Growth, not per capita)*

By 2020: GDP Growth result (not per capita)

- 7.1% (baseline) vs 6.9% (scenario)

(Model 3/3s sheets - Memorandum items)

(Can also run a similar simulation with a change in FDI rather than a change in debt)
Other simulations to run

• Model 1: Increase female labor force participation
  • See Bangladesh growth scenario example to right

• Model 2: GDP PC growth/levels
  • Investment required to grow at 4% vs 6%?

• An increase in human capital growth.

• Manual mode: choose values year-by-year
  • Choose “Manual” from dropdown menu and enter values in yellow cells on right
  • Useful if government sets annual targets in their planning documents

• Check sensitivity to initial parameters
  • Default K/Y, labor share sometimes drive results

Increasing Female Labor Force Participation
Baseline: 34% constant; Scenario: 60% by 2030

Notes: 1% TFP; 1.3% HC. I/Y: 29% → 34% (by 2020)
(vi) Simulations for YOUR COUNTRY (Model 1)

- InputDataA: Choose your country from drop down-down menu

Set up a baseline

- Choose parameters: Labor share ($\beta$) Depreciation ($\delta$), Initial Capital-Output Ratio ($\frac{K_0}{Y_0}$)
- Choose future assumptions: TFP Growth (A), Human Capital Growth (A), Investment/GDP (B)
- How to choose?
  - Compare data from different sources in “Data Summary” Tab (check if interpolated)
  - Choose data source (eg PWT 8.1, PWT 9) and length of average used (eg 10 yrs, 15 yrs) from drop down menus in InputDataA and InputDataB
  - Compare initial GDP or GDP Growth with trend in “Data Summary” Tab

- Set up a scenario
  - Change one thing in relative to baseline (eg increase in investment rate, increase TFP gr)
  - Choose target rate and year achieved
  - Check assumptions in baseline and scenario in Graphs A and Graphs B
Questions/comments/suggestions

• Latest version available as www.worldbank.org/LTGM (or just type “LTGM” on intranet)

• We are always trying to improve the LTGM -- comments and suggestions are welcome

• Further training to use the model (in person or via webex) is available

• Please contact us if you would like to use the model in your country: Steven Pennings (spennings@worldbank.org), Norman Loayza (nloayza@worldbank.org), or Jorge Guzmán (jguzmancorrea@worldbank.org) or LTGM@worldbank.org

• We can also provide help with analysis, in-country presentations, training govt officials etc
## Input/Output: Three Versions of the Model

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose</strong></td>
<td><strong>Growth</strong> given <strong>Investment</strong></td>
<td><strong>Investment</strong> given <strong>Output/Growth Target</strong></td>
<td><strong>Investment/Growth</strong> given <strong>Savings</strong></td>
</tr>
<tr>
<td><strong>Inputs:</strong></td>
<td>Investment rate ( \left( \frac{I_t}{Y_t} \right) )</td>
<td>Growth rate of GDP ( (g_Y) ) OR Growth rate of GDP per capita ( (g_Y^{pc}) ) OR Time path of GDP ( (GDP_t) ) OR Poverty</td>
<td>Savings rate ( \left( \frac{S_t}{Y_t} \right) )</td>
</tr>
<tr>
<td><strong>Outputs:</strong></td>
<td>Growth rate of GDP ( (g_Y) ), Growth rate of GDP per capita ( (g_Y^{pc}) ), Level of GDP ( (GDP_t) ), Poverty rate</td>
<td>Other three of the four measures</td>
<td>Growth rate of GDP ( (g_Y) ), Growth rate of GDP per capita ( (g_Y^{pc}) ), Level of GDP ( (GDP_t) ), Poverty rate</td>
</tr>
<tr>
<td><strong>Savings/Investment</strong></td>
<td>Savings rate ( \left( \frac{S_t}{Y_t} \right) )</td>
<td>Investment rate ( \left( \frac{I_t}{Y_t} \right) ), Savings rate ( \left( \frac{S_t}{Y_t} \right) )</td>
<td>Investment rate ( \left( \frac{I_t}{Y_t} \right) )</td>
</tr>
<tr>
<td><strong>External Sector</strong></td>
<td>CAB to GDP ( \left( \frac{CAB_t}{Y_t} \right) ) OR External Debt to GDP ( \left( \frac{D_t}{Y_t} \right) )</td>
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