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Public Investment in Bolivia: Prospects and Implications**Prepared by Yehenew Endegnanew and Dawit Tessema¹**

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Abstract

Bolivia's "Patriotic Agenda 2025" sets targets for social and economic development propelled by state-led industrialization under a five-year development plan (2016–2020). Large-scale public investment has aimed to fill infrastructure gaps and raise productivity to ensure sustained medium-term growth. Pursuit of these goals in a period of lower hydrocarbon revenues has, however, contributed to widening fiscal and external current account deficits. The paper uses a structural model to outline different scenarios for the level of public investment in the face of declining hydrocarbon revenues. It finds that if public investment is sustained at current levels as a share of GDP while hydrocarbon revenues continue to decline, the sustainability of the public debt could be called into question.

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I. BACKGROUND

Bolivia is a resource-rich country where extractive industries play a pivotal role. The natural gas and minerals sectors account for over 80 percent of exports, 20 percent of fiscal revenues and 10 percent of GDP. After Bolivia discovered large natural gas reserves in the late 1990s, gas production increased eight-fold between 1999 and 2015. With the last significant discovery in 2004—the *Incahuasi* field, production of gas has started to decline as existing gas fields mature (Toscani 2017).

Absent new discoveries, current natural gas reserves would last roughly 10 years. Proven gas reserves in Bolivia stood at 10.7 trillion cubic feet (TCF) in 2018. Continuation of historical production levels without additional discoveries would lead to depletion of reserves sometime in the mid-2020s. However, several natural gas exploration projects are in the pipeline which show significant potential. These big projects include *Boyuy* and *BoycoboRio Grande* and *Aguarague*, and *Acero* and *San Telmo*. The *Boyuy* project is in the traditional production zone and could come on stream soon.

Following the surge in hydrocarbon revenues, Bolivia increased public investment significantly over the past decade, although its efficiency has been less robust (see Annex D). Since 2006, public investment has grown at roughly 20 percent per year in nominal terms, doubling to 14 percent of GDP in 2015. Public investment accelerated with the timing of the five-year (2016–2020) *Plan de Desarrollo Económico y Social (PDES)*, coinciding with the 2014 drop in international oil (gas) prices. This was also part of the government’s countercyclical policies designed to support growth and incomes from the impact of the external shock. This strategy was effective at supporting growth, which averaged 4.8 percent during 2006 to 2017.

While counter-cyclical policies were effective at supporting growth, they resulted in large fiscal and external current account deficits—the “twin” deficits. The overall fiscal surplus recorded from 2010 to 2013 dropped to a deficit of 3.4 percent of GDP in 2014 and further to 7.8 percent of GDP in 2017. The external current account deficit widened to 6.3 percent of GDP in 2017 from a surplus of 1.7 percent of GDP in 2014. International reserves amounted to US\$10 billion (11 months of import cover) in 2017, having fallen from a peak of US\$15 billion in 2014. Gross (net) public debt rose to about 53.5 (39.6) percent of GDP in 2018 from about 37 (12) percent of GDP in 2013.

The purpose of this paper is to assess the growth and debt sustainability implications of different scenarios for public investment (being maintained at the recent average of 14 percent of GDP, gradually reduced to 9 percent of GDP, or a more abrupt reduction) alongside a hypothetical decline in hydrocarbon production. The scenario analysis draws on the Debt Investment Growth (DIG) model that captures the investment-growth nexus, as well as real frictions such as investment inefficiencies and absorptive capacity constraints.

We apply the model to Bolivia and compare the results of maintaining Bolivia’s current level of investment-GDP with a more moderate, smoothed path that incorporates some fiscal

consolidation. The scenario analysis examines two hypothetical resource sector revenue trajectories. The first assumes the possibility of an eventual depletion of reserves and the other assumes that new discoveries are able to sustain production beyond 2030.

The analysis shows that the impact of continued, ambitious public investment in the face of declining hydrocarbon revenues could push public debt levels to 100 percent of GDP by 2030. The analysis also shows that, if hydrocarbon revenues continue to fall, a gradual reduction in public investment levels to the peer average of 9 percent of GDP, could contain fiscal deficits and public debt levels while mitigating the adverse impact of the assumed decline in investment on economic growth.²

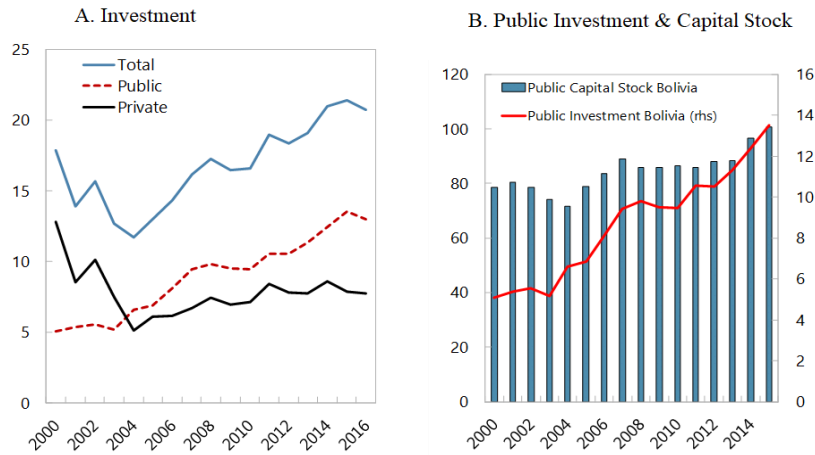
The paper is organized as follows: Section II discusses public investment trends in Bolivia. Section III describes the model and the key assumptions underlying the assessment. Section IV presents the results derived from the analysis for alternative scenarios and Section V provides additional sensitivity analyses. Section VI summarizes the main findings and concludes and highlights policy implications.

II. PUBLIC INVESTMENT IN BOLIVIA

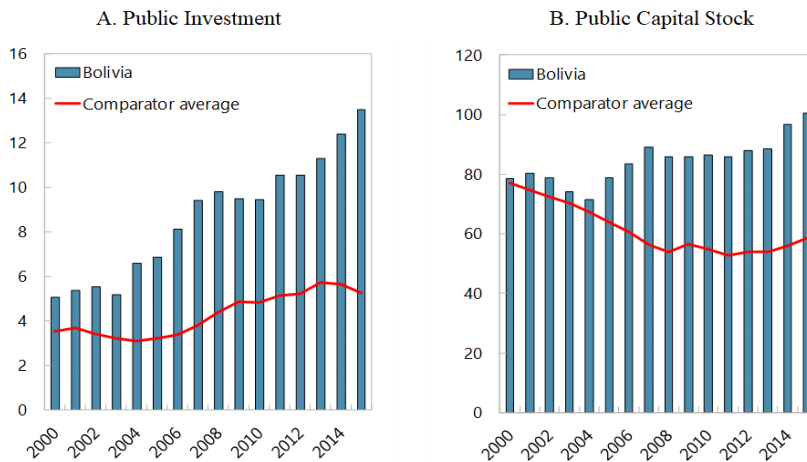
Bolivia enjoyed rapid growth in public investment during the past 12 years thanks to high hydrocarbon prices and revenues. According to IMF estimates, public investment doubled from 7 percent of GDP to 14 percent of GDP from 2005 to 2015, expanding the public capital stock from 78.8 percent to 100.5 percent of GDP during the same period (Figure 1.B). In terms of composition, two-thirds of capital spending consisted of infrastructure and investment in the productive sectors under a state-led industrialization model leveraging projects mainly in the hydrocarbon, energy, and mining sectors.

Bolivia's five-year development plan (*PDES*) comprises ambitious capital spending targets. Large-scale public investment aims to build infrastructure and raise productivity to deliver sustained medium-term growth. Under the *PDES*, the planned investment for 2015 to 2020 is estimated to be \$48.6 billion, 2.4 times more than the period 2006–14. Of the total planned investment, 56 percent would go to the productive sectors and 23 percent to infrastructure. The remaining 21 percent is allocated to social sectors and environment and water, consisting of irrigation projects, water resources, basic sanitation, housing, health, education and sports. The government is engaged in a comprehensive mid-term review of the Plan to assess progress and consider reorienting goals and the allocation of spending.

² The peer average is calculated as public investment (GDP) over 2012–17 for countries in the region with real per capita income levels ranging between US\$2500 and US\$5000.

Figure 1. Investment and Capital Stock (% GDP)

Sources: WEO and IMF staff estimates based on official data.

Figure 2. Public Investment and Capital Stock (% GDP)

Sources: WEO and IMF staff estimates based on official data.

Note: Comparator countries are Argentina, Brazil, Chile, Colombia, Ecuador, Paraguay, and Peru.

As a share of GDP, public investment and the capital stock are high compared to Bolivia's peers (Figure 2.A and 2.B). Public investment averaged around 14 percent of GDP during 2015–17, far exceeding the regional comparator country average of about 5 percent of GDP. As a result, the public capital stock in Bolivia has increased rapidly, although it remains low in per capita terms.

III. THE MODEL

The Debt-Investment-Growth (DIG) model, a dynamic general equilibrium model, is adapted to a small open economy with natural resource wealth. The model captures the investment-growth nexus in the presence of natural resource revenues, as well as constraints

to investment efficiency and absorptive capacity. The model serves to inform the authorities about the policy trade-offs related to investing resource revenues to boost growth-enhancing public spending with the need to maintain fiscal sustainability and macroeconomic stability.

The DIG model provides a suitable organizing framework to lay out the choices facing policymakers regarding policy trade-offs and different financing instruments. The model considers a small open economy with two production sectors, two types of households, and an active government that taxes, spends, and makes long-term investments. Under the model, intertemporal optimizing households have access to financial markets and rent capital to firms, while the remaining group of households have liquidity and borrowing constraints. While the first group is forward looking, the latter follows a rule of thumb that ties consumption decisions to income in each period. Goods are produced by a traded goods sector that hires factors of production and publicly provided capital. Public capital is generated by a non-traded goods sector using factors of production and labor and capital flow between sectors. The government collects taxes (income and consumption), and supplements domestic income by issuing bonds and providing grants. The government disburses earnings to finance public investment and government consumption and makes transfer payments to households. More details on the model and equations are provided in Annex I (see also (Buffie, et al. 2012) and (Melina, Yang and Zanna 2016)).

A. Different Public Investment Path Assumptions & Hydrocarbon Revenue Projections

The model is used to illustrate the policy implications of three alternative hypothetical public investment paths. This approach helps analyze the impact of various policy scenarios on the economic outlook. Each of the following policy simulations is a hypothetical path of public investment that captures three different strategies *current levels* of investment, *a gradual reduction*, and *a sharp consolidation*). The model uses these alternative public investment paths to produce comparable trajectories of key macroeconomic variables.

Alternate Public Investment Paths

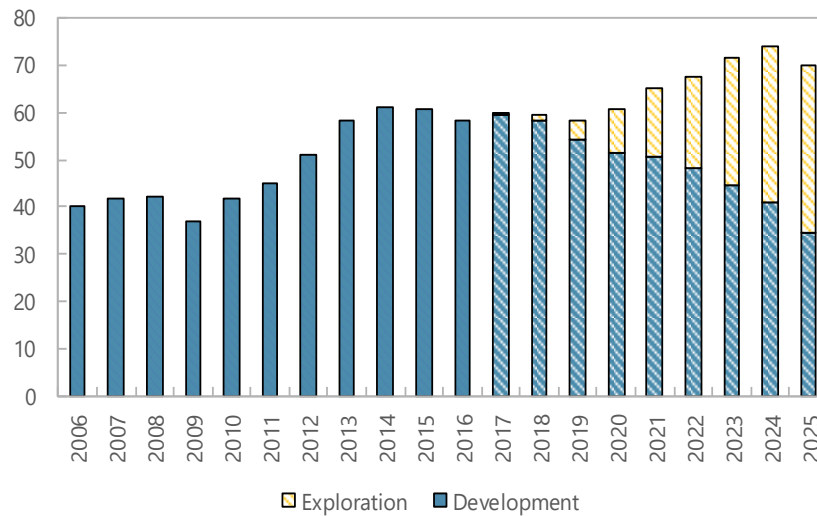
1. **Status quo:** This assumes that public investment is kept at the average annual level registered between 2012 and 2017 of 14.0 percent of GDP over the simulation period 2018–30.
2. **Gradual consolidation:** This path assumes a gradual consolidation of public investment from 14.0 percent of GDP to the peer average (9 percent of GDP) over the coming decade.
3. **Sharp consolidation:** The third and final path involves a sharp cut in public investment involving an adjustment from 14.0 percent of GDP percent of GDP to 9 percent of GDP in two years.

The public investment target of 9 percent of GDP is not only the peer average, but also derived from cross-country empirical evidence that demonstrates the importance of public investment for productivity in the tradable sectors. The economic rate of return (ERR) of projects implemented under undistorted macroeconomic environments, that is, with low inefficiency and a large absorptive capacity, is on average about 13 percent in countries where public investment as a share of GDP is 5 percent or less (Isham and Kaufmann 1999). Investment productivity declines as the share of public investment exceeds 10 percent of GDP. Based on similar cross-country evidence, (Fosu, Getachew and Ziesemer 2016) the growth and consumption maximizing levels of public investment are computed at about 10 percent of GDP and 8.1–9.6 percent of GDP, respectively.

Bolivia's existing natural gas reserves are expected to last for roughly 10 years assuming no additional discoveries. A study by a foreign company released in August 2018 estimated proven gas reserves (1P) in Bolivia at 10.7 trillion cubic feet compared to 10.45 trillion cubic feet in 2013. With constant production, and assuming no discoveries, current reserves would last until sometime in the mid-2020s.

Two natural gas revenue scenarios were considered. The first assumes a hypothetical depletion of reserves and the other assumes new discoveries that sustain production beyond 2030. Under the first conservative scenario, natural gas production and associated revenues decline in the absence of new discoveries. Natural gas output would decelerate and cease by 2025. The more favorable scenario assumes investment continues at a low level, generating some discoveries but not enough to replenish current reserves for the long term. As a result, output continues to fall but more gradually. The aim of the two scenarios is to examine the extent that the policy implications are affected by different assumptions about resource revenues.

- **Baseline scenario:** A hypothetical sharp decline in natural gas production reduces revenue from 6.2 percent of GDP to 1.7 percent of GDP by 2024. Gas revenues continue to decline over the remainder of the simulation horizon (2025–32). This gas revenue scenario is depicted by the blue bars in figure 3.
- **A more favorable scenario:** A more gradual decline in natural gas production is assumed that reduces revenue from 6.2 percent of GDP to 3.5 percent of GDP by 2024. Gas revenues also decline gradually over the remainder of the simulation horizon (2025–32).

Figure 3 Proven Natural Gas Reserves

Note: In millions of cubic meters per day. Figures for years 2017-2025 are projections from Yacimientos Petrolíferos Fiscales Bolivianos
Sources: YPFB data and IMF staff calculations, 2017.

B. Assumptions and Model Calibration

The model is calibrated using historical data and parameters consistent with the literature. Initial steady state values are derived using the latest observations of the relevant aggregate variables. Details on the calibration and parameterization for the model are given in Annex III, Table 1. Data on sector shares of GDP, tax rates, debt stocks and remittances are the latest Fund staff estimates. Bolivia's external debt at end-2017 stood at 24.1 percent of GDP while domestic debt is estimated at approximately 27 percent of GDP. The share of remittances in financial flows between 2013-2018 averaged 3.7 percent of GDP.

Domestic borrowing is used to finance public investment gaps that arise from lower a falling trajectory for natural gas revenue. This assumption rests on two key observations. First, Bolivia's fixed or stabilized exchange rate needs to be supported by sufficient foreign exchange reserves. In this light, international reserves are assumed to serve as buffers and not used to fund public investment. Second, the percentage of grants-to-revenue and grants-to-GDP over the period 2014–17 was a modest 0.9 and 0.2 percent, respectively, while tighter conditions in international capital markets and Bolivia's rising debt level are assumed to limit the availability of commercial financing from abroad. While tax financing of the fiscal gap is explored in Section V, a ceiling is placed on indirect taxes at 14 percent of GDP for the purposes of the following analyses. Section V examines how much adjustment in indirect taxes is required to maintain the current public investment path.

User fees on infrastructure services are assumed to recover at least half of the recurrent costs. This is set as an upper bound assumption given the absence of explicit data to calibrate this parameter. Average effective energy tariffs are known to be below cost recovery, while fuel

and gas prices are subsidized. For instance, the price of natural gas for domestic consumption is kept at a lower level than export prices (IMF, 2017). Similar arrangements exist elsewhere, where lower tariffs are applied to low-income households consuming up to 70 kWh/month (Di Bella, et al. 2015).

IV. SIMULATION RESULTS AND DISCUSSION

A. Baseline Scenario

Taking 2018 as a starting point, public investment is assumed to remain at 14 percent of GDP over the simulation period (2019–30). The government borrows domestically, including from the central bank, to finance the fiscal gap in the absence of a net increase in external concessional loans. We assume that historical borrowing patterns are maintained. Private banks and non-banking financial institutions (including the central bank) have accounted for 67 percent of the portfolio of public domestic debt (IMF, 2017).³

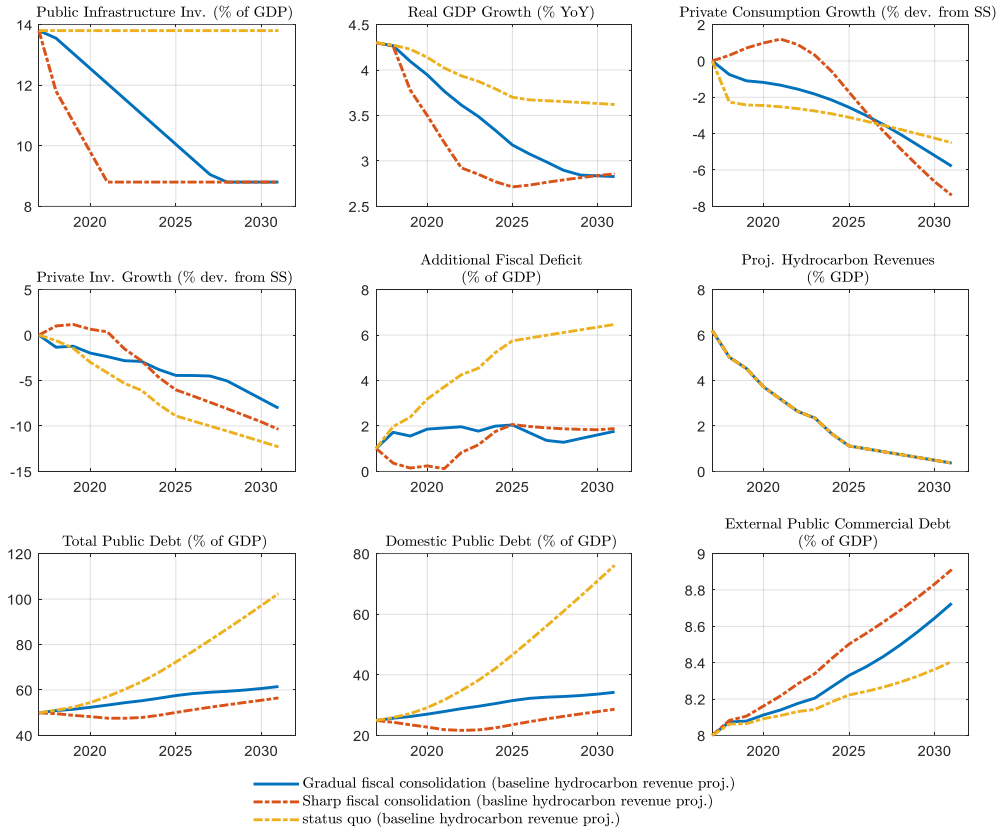
Figure 4 summarizes the short and long-run impacts of the different public investment paths assumptions noted above and under the hypothetical conservative natural gas revenue scenario.

1. Future hydrocarbon revenue falls from 6.2 percent of GDP in 2016 to 1.12 percent of GDP by 2025 and gradually tapers off by 2030 unless exploration efforts underway bear fruit. An unchanged (*status quo*) public investment path has several critical macroeconomic implications (depicted in yellow in Figure 4). Maintaining an elevated level of public investment with domestic borrowing supplementing fiscal shortfalls can lead to sharp declines in private investment growth, a rapid rise in the fiscal deficit above already high rates of around 7 percent of GDP, as well as a sizeable accumulation in public debt to over 100 percent of GDP by 2030.
2. Under the “gradual consolidation” path, public investment levels are assumed to steadily fall to 9 percent of GDP by 2027. These reductions imply a gradual decrease in private investment and consumption levels compared to the *status quo* fiscal path, owing largely to differences in anticipated future taxes. The gradual reduction in public investment leads to a lower fiscal deficit without a significant adverse impact on medium-term growth. Overall, public debt levels are kept near 60 percent of GDP.
3. The “sharp consolidation” scenario has a larger negative impact on medium-term growth rates. This scenario involves a sharp cut in public investment to 9 percent of GDP in two years. This adjustment leads to sharp losses in private investment and consumption growth in the medium term largely because public investment spending has been creating demand by generating jobs and supply chains across economic sectors. Fiscal deficits under this scenario for public investment are lower in the short-run but deficits in the

³ See Table 4, page 24. Public domestic debt includes central bank lending to SOEs.

long run are no lower than those under the gradual consolidation path because of the negative impact on growth. Public debt has a broadly similar trajectory under both the sharp and gradual investment consolidation paths (upper middle panel).

Figure 4. Baseline Scenario



Source: Authors' estimates.

Overall, the gradual investment consolidation path is able to stabilize debt and keep fiscal deficits at manageable levels while ensuring the negative impact on medium-term growth rates is contained.

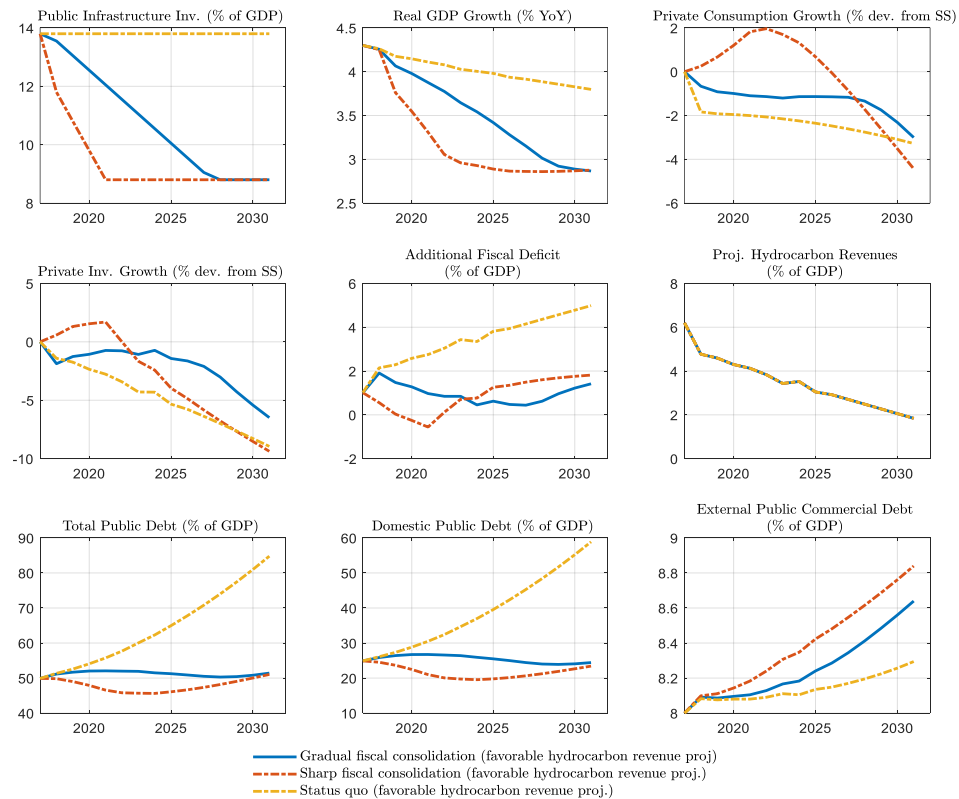
B. More Favorable Scenario

Figure 5 summarizes the short and long-run impacts of the three public investment paths under the more favorable hydrocarbon production scenario. Projected hydrocarbon revenue falls to 3.5 percent of GDP by 2024 from 6.2 percent of GDP in 2016 and gradually declines over the remainder of the simulation period (2025–30). Again, maintaining elevated levels of public investment with domestic borrowing supplementing fiscal shortfalls leads to more adverse macroeconomic outcomes (depicted in yellow): private investment and consumption fall substantially in the long-run, erasing the gains from higher medium-term growth. To put these numbers in perspective, recent rates of annual private consumption growth in Bolivia averaged 4.0-4.7 percent. Under the *status quo* investment scenario, consumption growth in the medium-term is lower by more than 2 percentage points (top right panel) and eventually

contracts by 2030. Total public debt is also high under this scenario as moderately slower growth and higher additional fiscal deficits result in a rapid debt build-up. Under these conditions, public debt would exceed 80 percent of GDP by 2030.

Under the gradual consolidation path, public investment levels are reduced steadily to 9 percent of GDP by 2027. Once again, these reductions imply only moderate contractions in public consumption and investment growth compared to the *status quo* investment path. Real private investment levels do not contract since historical real private investment growth at 9.8 percent since 2014 is higher than the decline in private investment growth under the gradual consolidation path, thus implying milder crowding-out effects than under the *status quo* investment path. These gains are matched by a lower fiscal deficit and smaller growth shortfalls. Public debt levels are kept near current levels around 50 percent of GDP.

Figure 5. More Favorable Scenario



Source: Authors' estimates.

Under the more favorable hydrocarbon revenue scenario, sharp investment consolidation would have a larger negative impact on medium-term growth. This measure not only extends private investment and consumption growth losses in the medium term, but also results in a substantial reduction in medium term growth rates. The latter affects private investment and consumption growth from 2021 until the end of the simulation period (upper middle panel). Even with a more favorable outlook for hydrocarbon revenues, a gradual reduction in investment protects growth and prevents a decline in private consumption and investment.

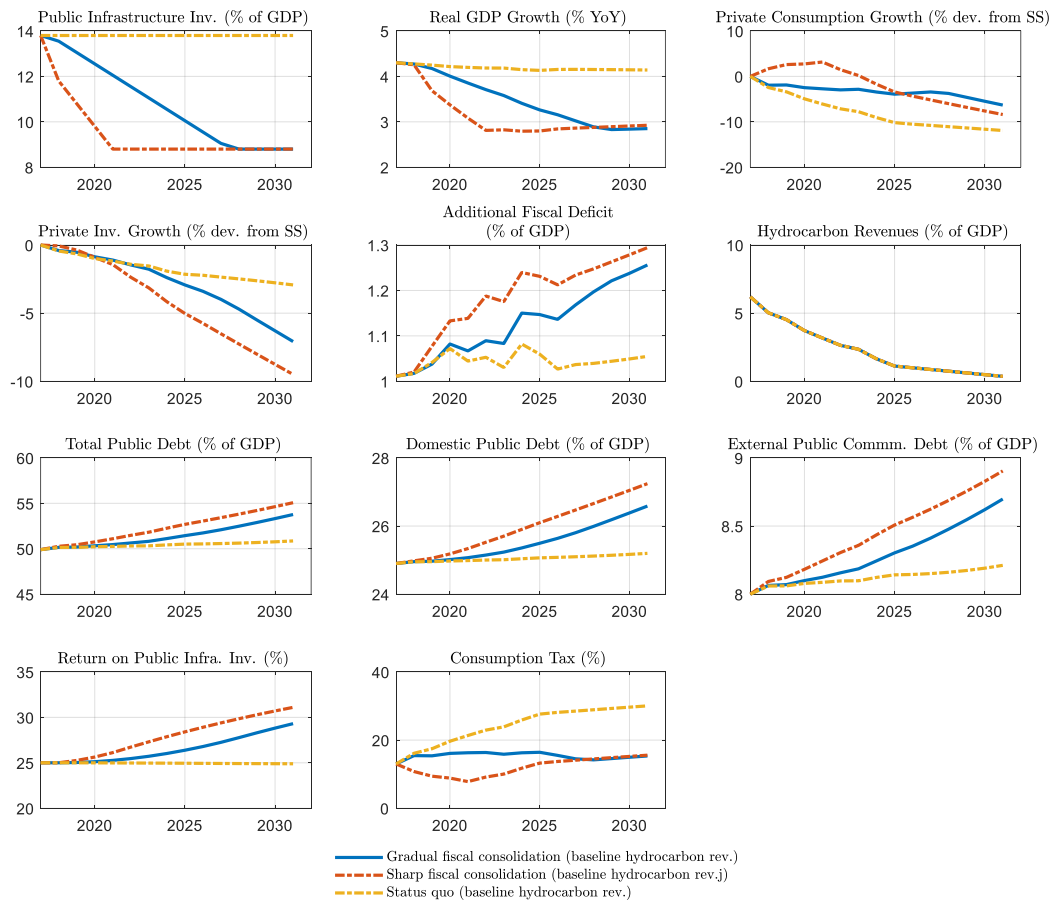
V. SENSITIVITY ANALYSES

In this section, we considered two additional fiscal scenarios. The first is an *endogenous adjustment* of indirect taxes as an alternative means to finance the fiscal shortfalls. This helps parameterize the amount of indirect tax increases that would be required to stabilize debt levels. The second scenario matches the three public investment paths with different likelihoods of new natural gas discoveries.

A. Endogenously Adjusting Indirect Taxes

Under the conservative hydrocarbon revenue scenario, the fiscal adjustment required to stabilize debt resulting from an unchanged public investment-GDP is captured in Figure 6 (lower/middle panel). These simulations show that reducing debt under this scenario will require indirect tax rates to rise to 20 percent (from an initial level of 13 percent in the first two years). This adjustment would weigh on private consumption. Maintaining public investment at current elevated levels does not stimulate economic activity since the scope for a reduction in future taxes in the long term is limited or removed.

Figure 6. Fiscal Gaps Covered by Indirect Tax Adjustment



Source: Authors' estimates.

As in the previous simulations, a scenario with a gradual consolidation of investment-GDP together with a modest increase in indirect taxes has a minor impact on growth while preserving debt close to current levels.

B. Natural Gas Discoveries Tied to Public Investment

Uncertainties about the long-term strength of natural gas exports could affect foreign investment in the sector (BMI 2018). The state-owned oil company, *Yacimientos Petrolíferos Fiscales Bolivianos (YPFB)*, considers the country underexplored, with estimates showing 48 percent of the territory with hydrocarbon (oil and gas) potential yet to be explored. The energy ministry expects that about 10.8 TCF worth of natural gas will be uncovered in the Tarija state by 2022, where 16 of Bolivia's 22 hydrocarbon exploration projects were underway in 2015 (BMI 2018).

Prospecting and exploration of oil and gas is managed by YPFB. Exploration, development and production efforts are largely financed by, and carried out in partnership with international oil companies. Private energy companies plan to invest US\$12.1 billion over the next five years to develop Bolivia's oil and gas resources (ibid). YPFB itself plans to invest US\$2.2 billion over five years into exploration and hydrocarbon derivatives aimed at adding value to gas production (ibid). The authorities' commitment to boosting overall output amid strong domestic and international demand will be supported by plans to disperse a majority of the US\$12.1 billion of FDI invested into the hydrocarbons sector through 2019 (ibid).

The probability of successful new gas discoveries will depend on the level of investment in exploration. The different scenarios presented in this paper assume a certain level of investment from foreign partners and from the Bolivian government. Each of the three-hydrocarbon revenue scenarios could thus be dependent on a certain level of public investment. We reformulate the scenarios to match the public investment paths as follows. Hydrocarbon revenues are assumed to fall sharply under a sharp reduction in investment while hydrocarbon revenues steadily decline under a gradual reduction of investment scenario. Finally, revenues under the *status quo* investment path are 30 percent higher than under the scenario where investment is gradually lowered.

Figure 7 summarizes the implications of future gas revenues that are dependent on the three public investment paths. Under current investment levels, public debt rises to 60 percent of GDP as gas revenues fall slowly. However, in this scenario there would likely be a need to increase expected future taxes in order to curtail the debt increase. As a result, the private consumption growth gradually falls below long-run historical levels in this scenario.

Under a gradual investment consolidation scenario, public debt stabilizes at current levels. The growth losses related to the assumed consolidation are relatively small and medium-term

domestic borrowing remains lower because of the consolidation. These results are robust to parameter variations within reasonable ranges⁴.

Figure 7. Natural Gas Discovery is Tied to Public Investment



Source: Authors' estimates.

VI. CONCLUSION AND POLICY IMPLICATIONS

This study applies a dynamic general equilibrium model to show the macroeconomic impacts of sustained high rates of public investment in the context of various hypothetical scenarios of hydrocarbon reserve depletion and declining projected hydrocarbon revenues. Under a conservative scenario, where there are no new natural gas discoveries, keeping public investment-GDP at current levels could push public debt levels to over 100 percent of GDP by 2030.

The model lays out alternative scenarios and examines the impact of different assumptions on the path of public investment. The exercise concludes that a gradual fiscal consolidation

⁴ Addressing identified weaknesses and gaps in public investment management would help increase the efficiency of capital spending in Bolivia (see Annex I). Simulation results show that debt levels would remain below 90 percent under the *status quo* investment path and conservative natural gas revenue projections when efficiency and investment returns improve. These are briefly demonstrated in the Annex III.

through lower public investment-GDP levels would contain increases in the public debt and result in relatively small output losses. Any remaining fiscal gap financed with domestic debt do not require to sharp future tax increases. Over the medium term, private consumption and investment growth, which are estimated to have accounted for 60 percent of the growth performance or nearly 3 percentage points of the average 4.7 percent real GDP growth rate since 2014, are likely to continue to drive growth. Gradual fiscal consolidation would support private consumption and investment growth and avert the possibility of boom-bust cycles down the road (particularly if financing availability becomes constrained).

The uncertainty and risks related to hydrocarbons exploration raise questions about the scope and timing of further upstream investments in the sector. Current fiscal deficits, hydrocarbon-related revenue risks, uncertain prospects for new discoveries and reserves, risks related to global oil/gas prices, and the risk of weaker demand from Brazil and/or Argentina point to the need for a prudent and restrained public investment plan that ensures fiscal sustainability and durable growth.

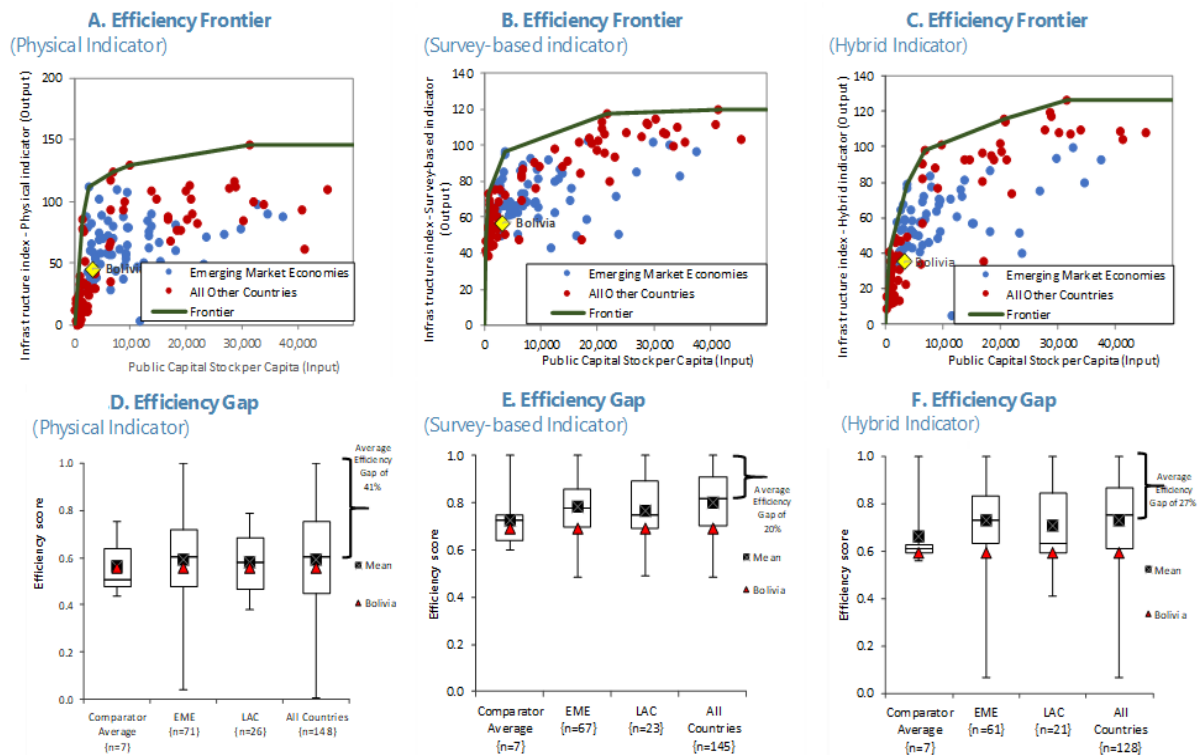
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Annex I. The Efficiency of Public Investment in Bolivia

The efficiency of public investment in Bolivia is assessed using an efficiency frontier analysis. The level of efficiency is represented by the distance of a country from the efficiency frontier, defined by the countries with the highest coverage and quality of infrastructure (output) for a given level of public capital stock (input) (IMF, 2015). A public investment efficiency score ranging between 0 and 1 is given to countries based on their vertical distance to the frontier relative to best peer performers. We used three measurements: (i) a physical indicator that combines data on the volume of economic and social infrastructure; (ii) a survey-based indicator based on the WEF's survey on the quality of key infrastructure; and (iii) a hybrid indicator that combines these two indicators into a synthetic index of the coverage and quality of infrastructure networks.

Figure 8. Public Investment Efficiency Relative to Frontiers



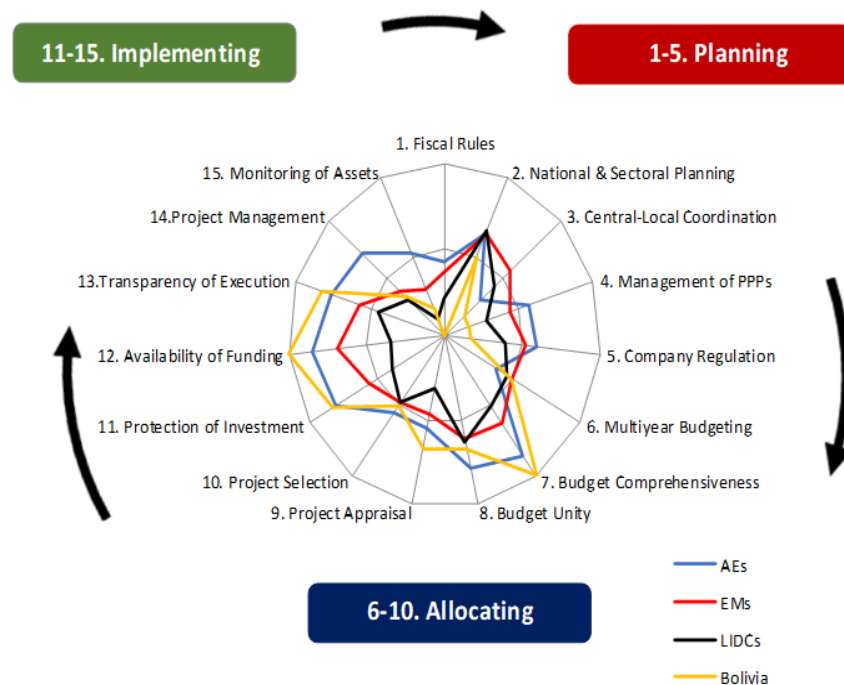
Source: IMF staff estimates. Efficiency frontiers are based on the 'Investment and Capital Stock Dataset' (IMF)

The analysis shows that there is substantial scope for improving public investment efficiency in Bolivia (Figure 8). Based on the hybrid indicator, the average efficiency gap in Bolivia is about 41 percent, well above the average gap of 27 percent for EMEs and 29 percent for LAC countries. Similarly, the average efficiency gaps based on the physical and survey-based indicators are about 31 percent and 45 percent, respectively, also higher than the average gaps in EMEs and LAC countries. The economic dividend from closing the public investment efficiency gap could be large.

To assess the quality of public investment management, we applied a desk review of the Public Investment Management Assessment (PIMA) framework¹ developed by the Fund’s Fiscal Affairs Department. The desk review evaluates 15 key institutions for planning, allocating, and implementing public investment. For each institution, three key design features are identified and assessed by Fund experts and three possible scores assigned: high, medium, and low. The scores are aggregated using simple averages and scores between 0 and 10 is assigned to countries.

The PIMA based on 2014 data finds that Bolivia’s institutions for public investment are relatively well developed, though performance is weak in a few areas. Figure 9 presents an overview of the strength of Bolivia’s public investment management institutions compared to the rest of the world. Based on the raw data provided in 2014, the PIMA overall score for Bolivia is 5, close to the average of EMEs. Bolivia’s relative performance at the planning stage is the weakest, but it strengthens along the allocation and implementation stages.

Figure 9. Strength of Public Investment Management Institutions



Source: IMF staff desk review, and a survey of the Bolivian authorities conducted in February 2015.

¹ This section summarizes a desk review of a PIMA and is not a substitute for a full PIMA. A full PIMA evaluation could yield different results from desk or other types of reviews of public investment management. The desk review presented here was done with 2014 information and based on (IMF 2015). In 2018, there was a publication of the “*Public Investment Management Assessment - Review and Update*” Policy Paper, which updated the PIMA framework principles.

Annex II. Key Features of the DIG Model

Firms

Firms operate in a two-sector environment and produce traded and non-traded goods q_x and q_n using private capital k , labor l and productivity enhancing public capital z^e . Each sector uses Cobb-Douglas production technology with differentiated private capital and labor that is mobile across sectors. Productivity is assumed to depend on two types of externalities. On the one hand, large scale production adds to knowledge about production techniques (learning-by-doing externalities captured by the second term in Eq1. On the other hand, private capital accumulation contributes to knowledge creation (a static externality captured by the third term in Eq2). These two effects prevent marginal product from declining. For $j = x, n$

$$q_{j,t} = A_{j,t} (z_{j,t}^e)^{\phi_j} k_{j,t}^{\alpha_j} l_{j,t}^{1-\alpha_j} \quad (1)$$

$$A_{j,t} = \alpha_j \left(\frac{q_{j,t-1}^l}{\bar{q}_j^l} \right)^{\alpha_j} \left(k_{j,t}^{\alpha_j} \right)^{\xi_j} \quad (2)$$

Infrastructure is built by combining one imported machine with a_i ($i = k, z$) units of a nontraded input, given its relative price P_n . The supply prices of private capital and infrastructure are given by:

$$P_{i,t} = P_{mm,t} + a_i P_{n,t} \quad (3)$$

Profit-maximizing firms equate the marginal value product of each input to its factor price. For $j = x, n$:

$$P_{j,t} (1 - \alpha_j) \frac{q_{j,t}}{l_{j,t}} = w_t \quad (4)$$

$$P_{j,t} \alpha_j \frac{q_{j,t}}{k_{j,t-1}} = r_{j,t} \quad (5)$$

Public budget constraint and fiscal adjustment

The government invests in public capital I_t , collects taxes $h_t p_t c_t$ and user fees on infrastructure services μz_t^e . It finances revenue shortfalls through domestic borrowing $\Delta b_t = b_t - b_{t-1}$, external concessional borrowing $\Delta d_t = d_t - d_{t-1}$, or external commercial borrowing $\Delta d_{c,t} = d_{c,t} - d_{c,t-1}$.

The government's budget constraint is given as follows:

$$p_t \Delta b_t + \Delta d_t + \Delta d_{c,t} = \frac{r_{t-1}-g}{1+g} p_t b_{t-1} + \frac{r_{d,t-1}-g}{1+g} d_{t-1} + \frac{r_{dc,t-1}-g}{1+g} d_{c,t-1} + Y_t \quad (6)$$

where $Y_t = p_{z,t} I_{z,t} + T_t - h_t p_t c_t - G_t - N_t - \mu Z_{t-1}^e$; and social transfers (T_t), grants (G_t), and natural resource revenue (N_t).

Public investment produces infrastructure according to a standard accumulation equation given by Eq. 7. However, not every dollar invested by the government generates productive capital, where $s, \bar{s} \in [0,1]$.

$$(1+g)z_t^e = (1-\delta)z_{t-1}^e + s(I_{z,t} - \bar{I}_z) + s\bar{I}_z \quad (7)$$

After choosing the public investment path and concessional borrowing, the government can elect to address the fiscal gap caused by revenue shortfall (e.g. natural gas revenue), either through domestic borrowing, external commercial borrowing, or a combination of tax adjustments $(h_t - h_o)p_t c_t$ and transfer allocations $T_t - T_o$.

$$fiGAP_t = p_t \Delta b_t + \Delta d_{c,t} + (h_t - h_o)p_t c_t - (T_t - T_o) \quad (8)$$

Optimizing Households

Optimizing and non-saving households are indexed by superscripts θ and η , respectively. Households consume the domestic traded good $c_{x,t}^i$, an imported traded good $c_{m,t}^i$ and a domestic non-traded good $c_{n,t}^i$, where $i = \theta_1, \theta_2$. The goods are combined into a CES basket with an intertemporal elasticity of substitution ε and a distribution parameter ρ_j such that $\sum_j \rho_j = 1$ for $j = x, m, n$.

$$c_t^i = \sum_j \left[\rho_j^{1/\varepsilon} (c_{j,t}^i)^{(\varepsilon-1)/\varepsilon} \right]^{\frac{\varepsilon}{\varepsilon-1}} \quad (9)$$

The demand functions for each good are expressed as $c_{j,t}^i = \rho_j p_{j,t}^{-\varepsilon} p_t^\varepsilon$. The household optimization problem is given as

$$\underset{c_t^\theta, b_t^\theta, i_{j,t}^\theta, k_{j,t}^\theta}{\operatorname{argmax}} \sum_{t=0}^{\infty} \beta^t \frac{(c_t^\theta)^{1-1/\tau}}{1-1/\tau} \quad (10)$$

Subject to the following budget constraint and capital accumulation equations

$$p_t b_t^\theta - b_t^{\theta*} = \sum_{j=n,x} r_{j,t} k_{j,t-1}^\theta + w_t k_t^\theta + Q_t - p_{k,t} (\sum_{j=n,x} I_{j,t}^\theta + AC_{j,t}^\theta + \Omega_{j,t}^\theta) - V_t \quad (11)$$

where $Q_t = \frac{R_t}{1+a} + \frac{T_t}{1+a} + \frac{1+r_{t-1}^*}{1+g} b_{t-1}^{\theta*} + \frac{1+r_{t-1}}{1+g} b_{t-1}^\theta$; and $V_t = p_t c_t^\theta (1 + h_t) + \mu Z_{t-1}^e + \Phi_t^\theta$

$$(1 + g)k_{j,t}^\theta = I_{j,t}^\theta + (1 - \delta)k_{j,t-1}^\theta \quad (12)$$

Saving households invest $i_{j,t}^\theta$ in private capital that depreciates at a rate δ . Households have access to a domestic bond b_t^θ and can contract foreign debt $b_t^{\theta*}$ at rates r_t and r_t^* . Households rent factors of production and earn income on labor w_t and capital $r_{j,t}$. Savers have a fixed labor supply l_t^θ and are assessed a fee μZ_{t-1}^e for infrastructure services, and a consumption tax h_t . Households receive remittances R_t , government transfers T_t and profits from firms Φ_t^θ and internalize firms' capital adjustment costs² $AC_{j,t}^\theta$ and portfolio adjustment costs $\Omega_{j,t}^\theta$.

Market Clearing Conditions

The labor market clearing condition is;

$$\sum_{j=x,n} l_{j,t} = \sum_{i=\theta,\eta} l_t^i \quad (13)$$

The good market clearing condition follows;

$$q_{j,t} = \varrho_j p_{j,t}^{-\varepsilon} p_t^\varepsilon c_t + a_k \sum_{j=x,n} (I_{j,t} + AC_{j,t}) + a_z I_{z,t} \quad (14)$$

The resource constraint is satisfied

$$\Delta b_t + \Delta d_t + \Delta d_{c,t} = \frac{r_{t-1}-g}{1+g} p_t b_{t-1} + \frac{r_{d,t-1}-g}{1+g} b_{t-1} + \frac{r_{dc,t-1}-g}{1+g} d_{c,t-1} + \Lambda_t \quad (15)$$

Where

$$\Lambda_t = p_{z,t} I_{z,t} + p_{k,t} \sum_{j=x,n} (I_{j,t} + AC_{j,t}) + p_t c_t - \sum_{j=x,n} p_{j,t} q_{j,t} - G_t - R_t - N_t \quad (16)$$

² The firm is unable to operate some of its equipment while its installing new machinery. On the other hand, portfolio adjustment costs are intended to capture costs to households from buying and selling of assets. The adjustment costs are, respectively, represented by $AC_{j,t}^\theta = \frac{\nu}{2} \left(\frac{i_{j,t}^2}{k_{j,t-1}^2} - \delta - g \right) k_{j,t-1}^\theta$ and $\Omega_{j,t}^\theta = \frac{\eta}{2} (b_t^\theta - \bar{b}_t^\theta)^2$

Annex III. Model Calibration

Table 1. Calibration of Key Parameters

Parameter	Parameter Description	Baseline (%)	Source
g	Trend growth rate	4.3	WEO/IFS
R	Remittances to GDP ratio	3.7	WEO/IFS
h_o	Consumption tax rate (VAT)	13	World Sales Tax Handbook
$I_{z,o}$	Public infrastructure investment to GDP ratio	14	AIV 2017
r_o	Initial return on infrastructure	25	Authors' computation
s	Efficiency of public infrastructure investment	60	Authors' computation
\bar{s}	Steady state efficiency of public investment	60	Authors' computation
b_o	Initial public domestic debt to GDP ratio	24.8	AIV 2017
d_o	Public concessional debt to GDP ratio	17	AIV 2017
$d_{c,o}$	Public external commercial debt to GDP ratio	8	AIV 2017
G	Grants to GDP ratio	0.2	AIV 2017
oil_g	Initial natural gas revenues to GDP ratio	6.2	Authorities data
b_0^*	Initial Private external debt to GDP ratio	0.0	AIV 2017
$r_{d,o}$	Real rate on public domestic debt	2.5	Authors' estimate
$r_{dc,o}$	Real rate on public external commercial debt	4.3	Authors' estimate
M_g	Initial Imports to GDP ratio	18	WEO/IFS
VA_{NT}	Value added in NT-sector	49.4	GTAP-IV
η/θ	Labor ratio of Non-Savers to Savers	2.00	Global Findex 2018
ξ_x	Learning externality in the T-sector	0.1	Buffie et al. (2012)
ξ_n	Learning externality in the NT-sector	0.1	Buffie et al. (2012)
α_x	The share of capital in value added in T-sector	40	Buffie et al. (2012)
α_n	The share of capital in value added in NT-sector	55	Buffie et al. (2012)

Annex IV. Additional Sensitivity Analyses

Additional sensitivity checks are performed in this section, by setting the public investment efficiency indicator (PIE-X) to top LAC performers. (Cerra, et al. 2016) estimated a PIE-X score of 0.73 for Chile among a sample of 16 LAC countries. The objective of this exercise is twofold (1) to show how much gains accrue to efficiency improvements when facing revenue shocks (2) to show how much macroeconomic outcomes are sensitive to the efficiency parameter. Figure 10 shows the favorable gas revenue scenario with efficiency levels set at 0.73. The results largely mimic those in figure 5 where efficiency levels are set at 0.6. The results largely mimic those in figure 5 where efficiency levels are set at 0.6.

Figure 10. Debt Trajectories under Higher Efficiency



Source: Authors' estimates.

Again, sharp investment consolidation would help maintain debt ratios at current levels but at the expense of medium-term growth, and private investment and consumption growth. Gradual investment consolidation is still the preferred strategy since it achieves manageable fiscal deficits and public debt levels with a lower negative impact to domestic absorption. While, the efficiency bump improves the public capital stock for every dollar spent and ultimately leads to higher output, the associated public debt reduction is not substantial under the status quo public investment plan. Public debt levels surge beyond 80 percent by 2030 under the status quo investment plan (when PIE-X=0.6). The same debt ratio reaches 70 percent when PIE-X is at 0.73.

Public investment efficiency improvements alone are not a panacea and need to be backed by sustainable investment plans. As in Figure 10, the results in Figure 11 reinforce this assertion. Figure 11 summarizes the implications of higher public investment efficiency under variable future gas revenues that are tied to the three public investment paths. Under the status quo, public debt edges up to 75 percent of GDP as gas revenues gradually fall and domestic debt is required to finance the remaining gap. The steady decline in gas revenues and gradual increase in domestic debt do signal an increase in expected future taxes. As a result, private consumption growth gradually falls below the long-run average. Under gradual consolidation, public debt is not worrisome since the growth losses related to consolidation are not large and medium-term domestic borrowing remains lower than under the status quo. Again, gradual consolidation is the favored strategy since it prevents sharp contractions of private consumption and investment growth. Results are fairly similar to Figure 7.

Figure 11. Debt Trajectories under High Efficiency and Variable Hydrocarbon Revenue



Source: Authors' estimates.