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**Working Paper**

# Poverty, indigence and public investment in Bolivia: A simulation analysis

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# Poverty, Indigence and Public Investment in Bolivia: A Simulation Analysis

*por:*
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*y Horacio Villegas Quino*

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## Abstract

The study of the impact of public investment on poverty is currently of particular importance due to, among other factors, the commitments that several countries have acquired in the framework of the Millennium Development Goals and the current political situation which gives a more prominent role the government in the economy.

We use a general equilibrium model to analyze the impact of public investment on income from various sectors of the economy. Subsequently, we use these results to impute income in the MECOVI 2007 survey. In this way, we calculate various measures of poverty and indigence, and analyze its evolution over time.

The estimated measurements indicate that public investment has a positive effect in reducing poverty and indigence in Bolivia, however this effect is small. The most important results are evident in the headcount index that is reduced about 3 points in a scenario of high public investment and 2 points in a scenario like the current investment. However, the results for the poverty gap and severity of poverty and indigence are more modest.



Keywords: General Equilibrium Model, MECOVI, Public Investment, Policy, Poverty
JEL-Code: C-68 H-54 Z-13

## 1. Introduction

The role of public investment over poverty reduction is emphasized by the UN Millenium Project (2005): If the government identifies appropriately elements of the investment focused on the poor´s empowerment, the economy could get an auto sustainable economic growth path and this sector could grasp the benefits of the global economy. In addition, the basis for the diversification of the exports and the promotion of the economic growth could also be achieved.

Also, as pointed out by Anderson, Renzio and Levy, 2006 "the poverty impact of public investment is particularly important at present because of the slow rates of progress toward the targets contained in the Millennium Development Goals".

From a theoretical perspective, there are many channels through which investment may affect the economy. At a macro level, is relevant the effect on growth, investment and aggregate productivity. At a micro level, there is a more sectoral approach, at the level of the firm, but also an analysis of household income, poverty and income distribution. In this sense, the general equilibrium allows to capture the magnitude and relationships of these effects. (Anderson, Renzio and Levy, 2006).

Additionally, the results of general equilibrium analysis can be used in household surveys to obtain more detailed results on poverty and income distribution. (Lay, Thiele and Wiebelt, 2008).

Moreover, from an empirical standpoint, the effect of public investment on poverty is not so significant. Between 1974 and 1982 many countries experienced large increases in public investment but the returns were low. (Little and Mirrless, 1990; Easterly, 2001).

This paper estimates the impact of public investment on poverty in Bolivia. We used a general equilibrium model (GEM) and the household survey, 2007 MECOVI.

Measuring the impact of the public investment over poverty is even more important in the current political and economic context considering that since Evo Morales took office, public investment has increased considerably.

The structure of the paper is as follows: The second part describes the GEM and the micro simulation over the MECOVI survey. The third part shows the results and the conclusions are in the fourth part.

## 2. The Bolivian General Equilibrium Model

The GEM is a tool designated to measure and evaluate the overall economic effects, including second order effects, related to external shocks or government policy intervention. This scheme aggregates numerically all market equilibrium conditions, therefore the model captures multiple simultaneous balances for different markets or sectors. The model surpasses any linear specifications (Shoven & Whalley 1992; Ginsburgh & Keyser 1997; Dixon et al. 1982; and Horridge, et al. 1993).

New computational advances introduced more programming possibilities to reproduce the economic dynamics by simulating partial or general equilibriums. In this research we use a dynamic third generation GEM with the purpose to evaluate poverty effects in the short and medium term (Pereira & Shoven, 1988; Decaluwé & Martens, 1988).

The closures of our model verify the neoclassical macroeconomic restructuring of portfolio assets, sectoral production changes and income distribution - in different scenarios, like structural adjustment and policy planning (Bourguignon et al., 1989; Rosenzweig & Taylor, 1990 & Jemio, 1993, 2001a,b). It also combines the assumption of optimal consumption and portfolio composition – following the recommendation of Agénor et al. (2002); Heathcote (1998) & Silva (2004).

### 2.1. The Markets: Goods and Factors

The markets of goods and factors of production are modeled according to the following standard assumptions for a GEM:

1) The capital is fixed in the short term.
2) The function of production has a constant elasticity of substitution (CES) for the following sectors: agriculture, oil, natural gas, mining and services. The CES function has a consistent system of equations, including a CES function of costs and individual demand functions for the factors of production and inputs, derived from the application of the Shepard Lem.
3) Small and price taker country in the agriculture, oil, natural gas, mining and services sectors. The commercial fluxes of exports and imports adjust for any difference between supply and demand. For modeling purposes, the Armington (1969) assumptions are considered.
4) The CES functions also determine the demand for capital, labor and imported inputs in those sectors and have identical elasticity of substitution.
5) Manufacturing and construction sectors have an oligopolistic market structure. The labor demand and the demand for intermediate imported inputs have a fixed relationship with the product. For that reason, adjusts can only happen until a maximum level of production determined by the imports capacity, this constitutes a foreign currencies restriction. A restriction of skilled labor can also exist. When one of those restrictions is met, prices are adjusted towards the equilibrium.
6) There is an urban and informal sector, which prices are fixed trough a mark-up over the profits, because this represents an excess of installed capacity, which allows supply to adjust according to the demand. Labor is self determined and wages are determined by the annual per capita production. When the labor quantity is fixed, demand adjusts through a decrease in the production and the per-capita income.
7) The supply of imports as well as the demand for exports are perfectly elastic.

8) The demand for imports is related to the income or the production, with a restricted price elasticity of substitution. The demand for imported inputs is part of the CES production function in those sectors that have functions of production and maintain a fixed relationship with the product in those sectors that have a mark up over their profits. The imports o capital goods are a fixed proportion of the investment in the base year and the consumer goods imports are determined by a Lineal Expenditure System (LES) and depend on the income and the relative prices.

## 2.2. The Financial Sector

The model aims for analyzing the institutional and redistributive relationships. For that reason 9 categories of financial institutions were chosen because of their importance: households, public enterprises, private firms, the government, the external sector, the Central Bank of Bolivia (CBB), the private/commercial banks (PB), other financial institutions and the pensions funds (PF).

For each one of these institutions, the lending and portfolio behavior are modeled according to the equilibrium identity of the Social Accountability Matrix (SAM). For each institution total assets should be equal to the liabilities plus the net wealth (Thiele and Piazolo, 2003).

For modeling purposes, 5 types of conventional assets/liabilities are considered, each of them has a different return rate or cost (except currency). Physical capital, public assets/liabilities, national currency, private assets/liabilities and the external assets/liabilities are considered.

It is also assumed that the financial restrictions are different and depend on the property schemes of each institution. Because of the size of the households (which includes informal businesses) a saving-first adjust approach has been modeled. The effective level of investment and the accumulation of other financial assets are adjusted to the availability of funds for the households, which follow profitability criteria.

For the private firms, the public enterprises and the government, it is assumed that they define their level and structure of assets/liabilities and that funding is assured (investment precedes savings approach). However, the levels of physical and financial investment can be restricted by their own saving capacity, foreign currency availability and the capacity of getting loans from the banking sector.

Regarding the lending relationship, the level of investment is restricted for the foreign currencies, depends on the import capacity and is determined with the external equilibrium and other requirements over the imports capacity (demand for consumption and intermediate imports). The saving capacity is a function of the profits of the firms and the income of the government respectively, whereas the availability of banking loans depends on the demand for deposits of the households.

The demand functions[1] for assets determine the total demand for liabilities, assuming a funding system determined by the supply (credit shortage) and an elastic demand for liabilities. It is important to notice that there is a specific closure rule for each institution, which determines the effective budget restriction applicable or each case. Therefore the credit availability for funding the investment demand depend on the entry of foreign capitals, the demand for assets for each agent, the CBB's management of the foreign reserves and the credit.

The firms have restrictions to accede to loans from the commercial banks and other financial institutions (restrictions due to reserves requirements, bank deposits and other liabilities), that match their accounts through credits from the CBB to the PB. The CBB restricts the foreign reserves and assumes the role of last resort lender of the government, and therefore affect to the investment of the private firms is restricted budgetary by this monetary control and the public demand for credits.

Finally, the demands for physical investment are policy variables since they are exogenous for the public enterprises and the government. Considering that in the macroeconomic approach it is not possible to capture adequately the link between the public spending, the productivity and the income distribution, both the production growth and the accumulation of human capital are considered exogenous.

Because of these assumptions the model approximates to a multi-sector and multi-institutional version of GEM, that corresponds to a Three Branch Approach (e.g. Taylor, 1990)[2] for the case in which the institutional investment is located within the limits of the restrictions of funding and foreign currencies. In this kind of models the limitations to the investment (economic growth) are analyzed. These limitations occur because of internal savings, external savings and public budget gaps. Formally, is an exercise which main objective is to maximize the investment (as a proxy variable of the economic growth rate).

### 2.3. Policy Variables in the Model

The effectiveness of the policy intervention is determined by its institutional context, the assumed sectoral adjust and the effect of external shocks (changes in world prices, international interest rates, decisions over foreign direct investment, portfolio and foreign assistance). The model characterizes an economy with institutions that have their own rules of behavior as well as a group of segmented and imperfect markets.

In this sense, the tools of internal policy are the nominal exchange rate, the minimum level of foreign reserves and the interest rate that the CBB charges, the level of consumption and public investment of the government and the tax aliquots among other variables. On the other hand, the commercial surplus and the accumulation balances are affected by the

[1] Most demand functions for assets are CES type depending on the relative profitability of the different securities in the system.

[2] The gaps of investment funding and foreign currencies are defined for each institutional sector. The impact of the intermediation, the relative prices and the profitability will also differ for each institutional agent. The CBB acts over the financial sector gaps through the management of foreign reserves.

imports capacity and the domestic prices. The supply of exports and the demand for imports depend on their respective price elasticities assigned in the model.

### 2.4. Macroeconomic Closures

One of the key aspects of the model is the election of the policy closure, which depends on the system of equations with define it (Rattso, 1982). It can be established closures over the factor market, the public sector, the external equilibrium, the foreign sector and the borrowable relationships (Dewatripont y Michel, 1987). Among the possible closures we have the neoclassical approach, Johansen´s and the Keynesian. A detailed description can be found on Thurlow y Van Seventer (2002).

A necessary but not sufficient condition is that the value of the savings generated by an economy is equal to the investment in the short run. However, in general they coincide partially because there are mechanisms that affect the behavior of its harmonization. Two approaches are widely used for explaining the equalization process; the first is the classical where the wages are totally flexible and adjust to keep the equilibrium of supply and demand in the labor market (which is the full employment level). In this case, unemployment can only occur if the real wage is above the market equilibrium level. The second approach is the Keynesian, where the nominal prices don´t adjust automatically to keep the equilibrium in the labor market.

The GEM used in planning usually present specific closures between these two approaches. Previously we stated that the households follow a savings-first approach and the private firms, the public enterprises and the government follows an investment-precedes-savings approach. Among the possible combinations the first closure is the total adjust over investment or mandatory savings while the second is the adjustment by the investment funding. Within the former, there are two modalities: an adjustment for external borrowing and a fiscal adjustment either by public spending or by the modification of a policy tool.

The adjustment by compulsory is neoclassical, this means that in the closure the investment is a function of the internal savings available for a given level o extern savings. On the other hand, the adjustment by the investment funding is Keynesian; in this case the investment is what determines the savings. Therefore, the external savings exogenously adjusts to the investment level.

### 2.5. Link Between the Model and Household Data

We follow the methodology suggested by Lay, Thiele and Wiebelt, 2008. We identified the components of household income in the GEM as well as in the household survey. The link between GEM and the survey is simply sequential: each individual factor income in the household survey is scaled up or down according to the GEM results. This is how changes in the GEM affect the distribution of income in the MECOVI survey.

## 3. Results

### 3.1. Assumptions

The simulated investment scenarios in the GEM are:

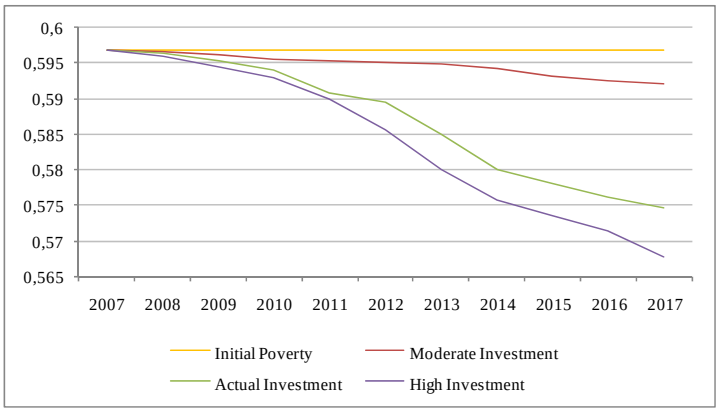
1. A moderate investment scenario assumes that this is growing at 5%.
2. A scenario like the current investment, which takes a proxy of the average investment growth from the new government (10%).
3. A high investment scenario assumes that this increases to 15%.
4. The simulation period covers the period 2007-2017.

### 3.2. The impact over poverty

Foster, Greer and Thorbecke (1984) propose measures of poverty based on the calculation of a poverty line. $P_0$, $P_1$ and $P_2$ respectively represent the percentage of poor or Poverty Headcount Index, the Poverty Gap Index and Severity Index Poverty. We use these measurements to estimate the impact of public investment on poverty.

Figure 1 shows the impact of investment on $P_0$ in the three scenarios described in Section 3.1. 2007 $P_0$ has a value of 0.5968. In this sense, the moderate investment scenario reveals a small effect on poverty, reaching $P_0$ a value of 0.5921 in 2017. In contrast, the current investment scenario is more effective since the counting rate reaches a value of 0.5747 in 2017. Finally, the stage for further intervention reduced headcount by almost 3 points, reaching a value of 0.5677.

**Figure 1: Poverty headcount index ($P_0$)**
(2007 – 2017)

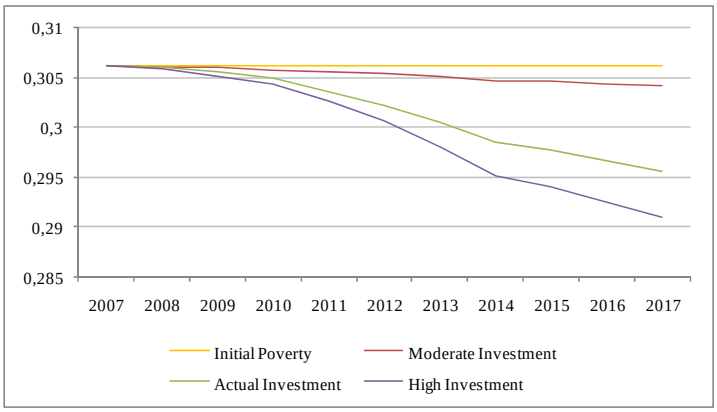



Source: Authors' calculations.

Figure 2 shows the effects of public investment on poverty gap. $P_1$ has an initial value of 0.3062 in 2007. For the year 2017, the moderate investment scenario shows a slight effect

on poverty, reaching a value of 0.3042. The current investment scenario, however, shows a more attractive; $P_1$ reaches a value of 0.2956 in 2017. Finally, the scenario of increased public investment reduces $P_1$ to a value of 0.2910 in 2017 (more than one and a half percentage points in the period).

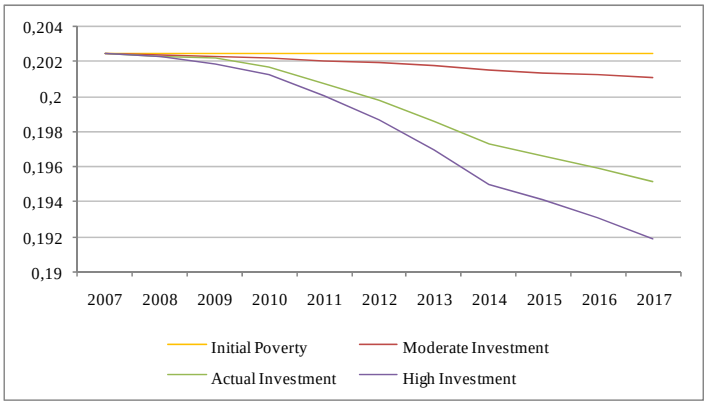
**Figure 2: Poverty gap index ($P_1$)**
(2007 – 2017)




Source: Authors' calculations.

The severity of poverty represented in Figure 3, begins 2007 with an initial value of 0.2025. In the moderate investment scenario a very small impact can be seen of public investment on $P_2$, since this indicator reaches a value of 0.2011in 2017. For the same year, in the current investment scenario, the poverty severity index reaches the value of 0.1951, while in the scenario of increased investment, the value obtained is 0.1919, which implies an improvement more than one point from the initial value.

**Figure 3: Poverty severity index ($P_2$)**
(2007 – 2017)

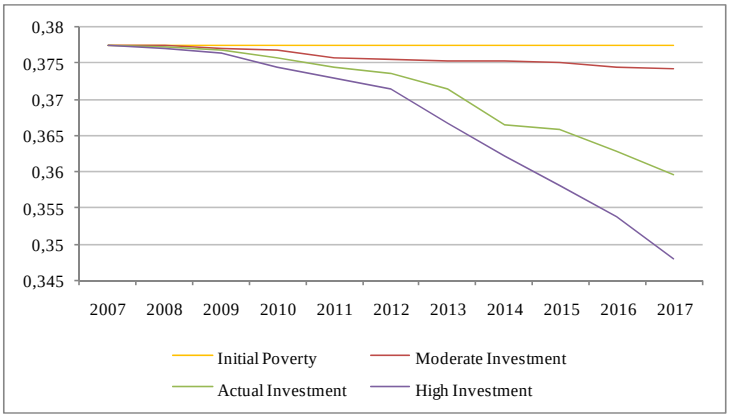



Source: Authors' calculations.

### 3.3. The impact over indigence

In Figure 4 the headcount index starts with a value of 0.3774 in 2007. The pattern of impact is very similar to that considered in the previous graphs: The moderate investment scenario reveals a slight effect on indigence by 2017, reaching a value of 0.3743; In the current investment scenario $P_0$ reaches a value of 0.3596 to 2017 while the more involved scenario makes the headcount will be reduced by almost 3 points, reaching a value of 0.3480.

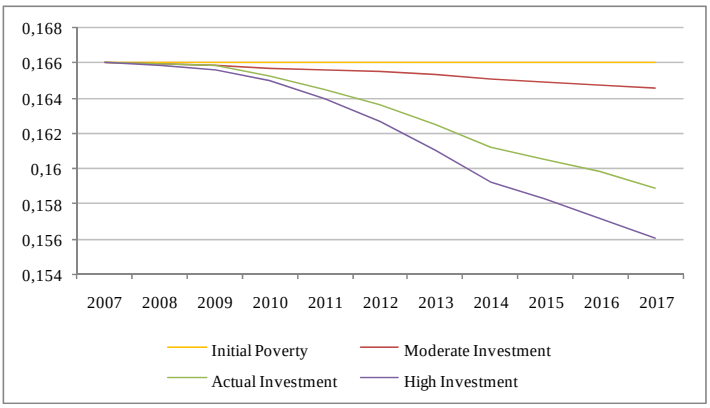
**Figure 4: Headcount poverty index ($P_0$)**
(2007 – 2017)




Source: Authors' calculations.

We also analyze the results for the $P_1$ index shown in the Figure 5. In 2007, the poverty gap starts with a value of 0.1660 and in 2017, the low investment scenario; it reaches a value of 0.1646. The current investment scenario however reaches a value of 0.1589 and the highest investment value of 0.1560, reducing the gap in exactly one percentage point

**Figure 5: Poverty gap index ($P_1$)**
(2007 – 2017)

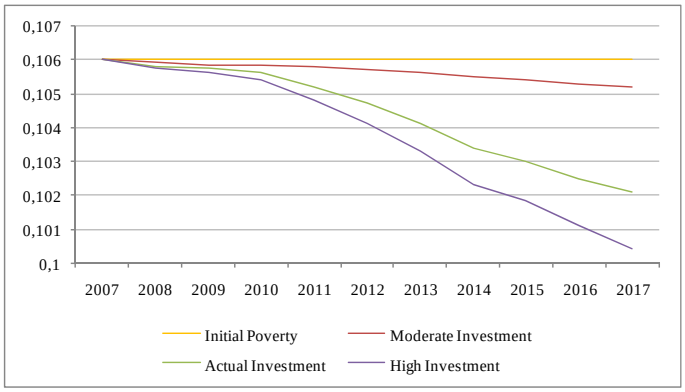



Source: Authors' calculations.

Finally, we note that the severity of poverty shows a behavior similar to that of poverty. As shown in Figure 6, the index $P_2$ begins with a value of 0.1060. The year 2017,

the severity of poverty decreases lightly (it reaches a value of 0.1052) in the moderate investment scenario, more rapidly (reaching a value of 0.1021) in the current investment scenario and ends with a value of 0.1004 in the high investment scenario.

**Figure 6: Indigence severity index ($P_2$)**
(2007 – 2017)



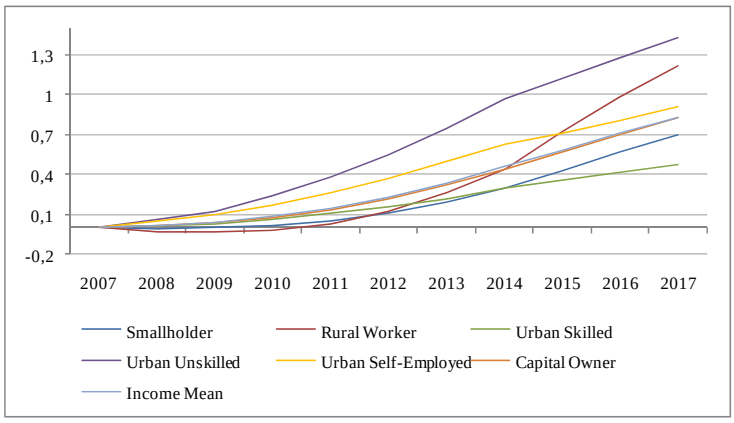

Source: Authors' calculations.

## 3.4. Moderate Scenario

Tables 1, 2 and 3 in the annex show the impact of public investment on poverty and indigence under the three scenarios analyzed. As seen in Table 1, while there is a change in the indicators over the period of analysis, it is quite small ($P_0$, $P_1$ and $P_2$ show differences only in the third digit).

Since $P_0$, $P_1$ and $P_2$ depend on individual income, in Figure 7 we analyze the growth rate of per capita income by sector. The average increase is more than 37 percentage points, being the most favored sector the urban unskilled and urban self-employed, with an average growth of 68% and 45% respectively. Other sectors, such as urban or for qualifying families get a lower return.

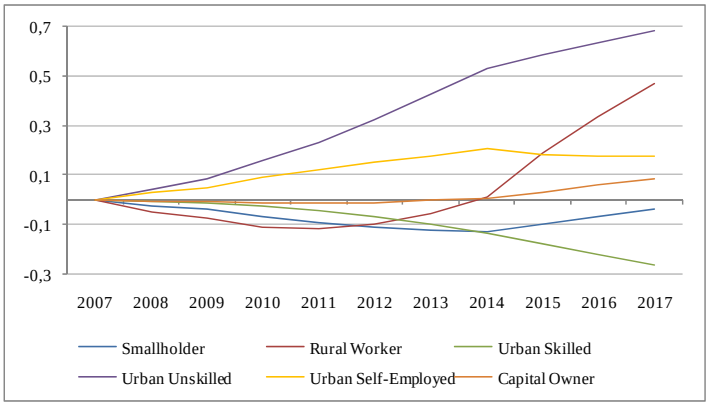
**Figure 7: Growth rate of per capita income by sector**
(2007 – 2017)




Source: Authors' calculations.

Similarly, if we observe the evolution of the growth rate of disposable income (Figure 8), we see that the disadvantaged are urban families and qualified, demonstrating a negative trend throughout the period. In contrast, the urban unskilled and urban self-employed are the most favored sectors showing positive rates during the period. Finally, rural workers experience a negative impact on the early years and a positive one during the last years.

**Figure 8: Growth rate of disposable income**
(2007 – 2017)

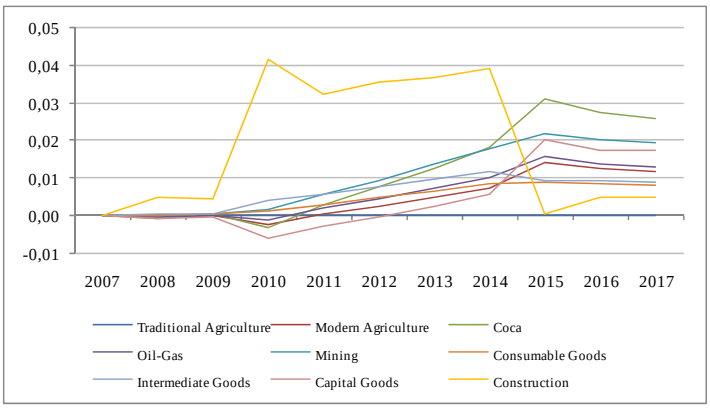



Source: Authors' calculations.

## 3.5. Current scenario

The impact on employment in a moderate investment scenario is analyzed in Figure 9. Construction is the most dynamic sector experiencing employment growth rates quite high during the period 2009-2015. Moreover, the areas of coca and mining have the more pronounced trends in the group.

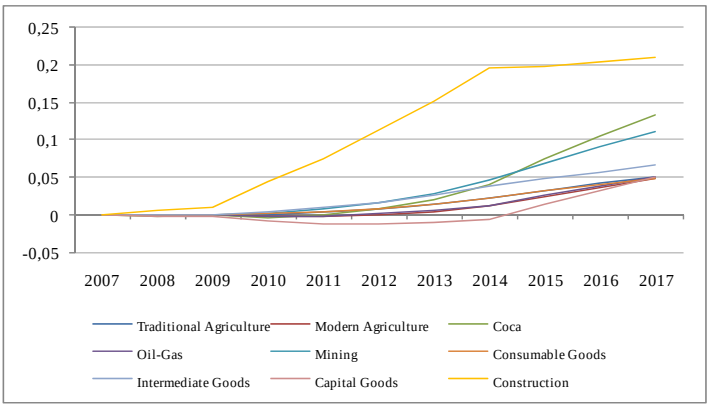
**Figure 9: Growth rate of employment by sector**
(2007 – 2017)




Source: Authors' calculations.

The increased employment is reflected in increased real output. In this sense, the most benefited sectors are again construction, coca and mining. By contrast, traditional agriculture and modern agriculture have a relatively low production growth.

**Figure 10: Growth rate of real production by sector**
(2007 – 2017)

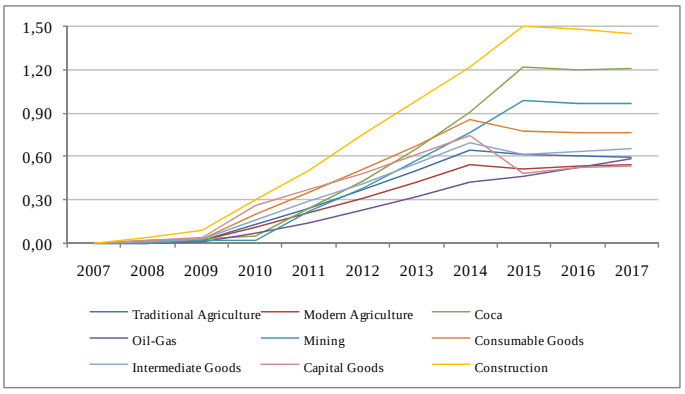



Source: Authors' calculations.

## 3.6. Higher intervention scenario

In a scenario of high public investment, the employment and production pattern is very similar to an investment scenario like the current: The construction, mining and coca experience significant increases in employment and sectoral output, which is reflected in increased consumption (Figure 11).

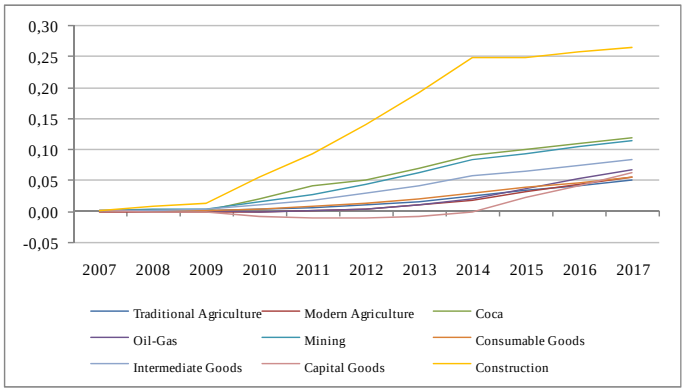
**Figure 11: Consumption growth rate by sector**
(2007 – 2017)




Source: Prepared based on CGE

Finally, Figure 12 shows the impact of public investment on real demand. Increased consumption promotes the expansion of aggregate demand, particularly in the sectors of construction, coca, and mining. Just as the increased employment translates into increased production, in this case the higher consumption increases demand.

**Figure 12: Growth rate of real demand by sector**
(2007 – 2017)




Source: Authors' calculations.

## 4. Conclusions

Using a computable general equilibrium model and applying a microsimulation on MECOVI Survey of 2007, we have found that public investment has a positive effect in reducing poverty and indigence in Bolivia. Using the measures $P_0$, $P_1$ y $P_2$ it has been verified the decrease in the three simulated scenarios: moderate investment (5%), current investment (10%) and high investment (15%).

However, the reduction of these measures is small. The most important results are evident in the poverty headcount index that is reduced about 3 percentage points in a scenario of high public investment and 2 percentage points in a scenario like the current investment. However, the results for the gap index and severity index are more modest.

The results show that investment in a scenario like the current one or one with more investment, the most benefited sectors are construction, mining and coca, which generate new sources of jobs, increase production and expand aggregate demand through consumption. On the other hand, in a moderate investment scenario, the most favored are unskilled urban and urban self-employed.

This study did not take into account the transfers that launched the current government (Juancito Pinto, Juana Azurduy, etc.) because these are not part of public investment and are rather considered as a component of public expenditure. The impact of these transfers on poverty and indigence are proposed as topics for future research.

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## Annex

Table 1: Poverty and indigence when public investment grows by 5%
(2007 – 2017)

| Year | Poverty | | | Indigence | | |
|---|---|---|---|---|---|---|
| | $P_0$ | $P_1$ | $P_2$ | $P_0$ | $P_1$ | $P_2$ |
| 2007 | 0.5968 | 0.3062 | 0.2025 | 0.3774 | 0.1660 | 0.1060 |
| 2008 | 0.5965 | 0.3061 | 0.2024 | 0.3773 | 0.1659 | 0.1059 |
| 2009 | 0.5961 | 0.3060 | 0.2023 | 0.3769 | 0.1658 | 0.1059 |
| 2010 | 0.5956 | 0.3058 | 0.2022 | 0.3767 | 0.1657 | 0.1058 |
| 2011 | 0.5953 | 0.3056 | 0.2021 | 0.3757 | 0.1656 | 0.1058 |
| 2012 | 0.5951 | 0.3054 | 0.2020 | 0.3755 | 0.1655 | 0.1057 |
| 2013 | 0.5949 | 0.3051 | 0.2018 | 0.3754 | 0.1653 | 0.1056 |
| 2014 | 0.5943 | 0.3047 | 0.2015 | 0.3753 | 0.1651 | 0.1055 |
| 2015 | 0.5931 | 0.3046 | 0.2014 | 0.3751 | 0.1649 | 0.1054 |
| 2016 | 0.5926 | 0.3044 | 0.2013 | 0.3746 | 0.1648 | 0.1053 |
| 2017 | 0.5921 | 0.3042 | 0.2011 | 0.3743 | 0.1646 | 0.1052 |

Source: Authors' calculations.

Table 2: Poverty and indigence when public investment grows by 10%
(2007 – 2017)

| Year | Poverty | | | Indigence | | |
|---|---|---|---|---|---|---|
| | $P_0$ | $P_1$ | $P_2$ | $P_0$ | $P_1$ | $P_2$ |
| 2007 | 0.5968 | 0.3062 | 0.2025 | 0.3774 | 0.1660 | 0.1060 |
| 2008 | 0.5963 | 0.3060 | 0.2023 | 0.3772 | 0.1659 | 0.1058 |
| 2009 | 0.5953 | 0.3056 | 0.2022 | 0.3767 | 0.1658 | 0.1058 |
| 2010 | 0.5941 | 0.3049 | 0.2017 | 0.3756 | 0.1652 | 0.1056 |
| 2011 | 0.5908 | 0.3036 | 0.2008 | 0.3743 | 0.1645 | 0.1052 |
| 2012 | 0.5896 | 0.3022 | 0.1998 | 0.3736 | 0.1636 | 0.1047 |
| 2013 | 0.5851 | 0.3005 | 0.1986 | 0.3714 | 0.1625 | 0.1041 |
| 2014 | 0.5801 | 0.2985 | 0.1973 | 0.3664 | 0.1612 | 0.1034 |
| 2015 | 0.5782 | 0.2977 | 0.1966 | 0.3659 | 0.1605 | 0.1030 |
| 2016 | 0.5761 | 0.2967 | 0.1959 | 0.3629 | 0.1598 | 0.1025 |
| 2017 | 0.5747 | 0.2956 | 0.1951 | 0.3596 | 0.1589 | 0.1021 |

Source: Authors' calculations.

Table 3: Poverty and indigence when public investment grows by 15%
(2007 – 2017)

| Year | Poverty | | | Indigence | | |
|---|---|---|---|---|---|---|
| | $P_0$ | $P_1$ | $P_2$ | $P_0$ | $P_1$ | $P_2$ |
| 2007 | 0.5968 | 0.3062 | 0.2025 | 0.3774 | 0.1660 | 0.1060 |
| 2008 | 0.5960 | 0.3059 | 0.2023 | 0.3770 | 0.1658 | 0.1058 |
| 2009 | 0.5945 | 0.3052 | 0.2019 | 0.3763 | 0.1656 | 0.1056 |
| 2010 | 0.5929 | 0.3044 | 0.2013 | 0.3745 | 0.1650 | 0.1054 |
| 2011 | 0.5900 | 0.3027 | 0.2001 | 0.3730 | 0.1639 | 0.1048 |
| 2012 | 0.5856 | 0.3006 | 0.1987 | 0.3714 | 0.1626 | 0.1041 |
| 2013 | 0.5799 | 0.2981 | 0.1970 | 0.3667 | 0.1610 | 0.1033 |
| 2014 | 0.5757 | 0.2952 | 0.1950 | 0.3622 | 0.1592 | 0.1023 |
| 2015 | 0.5735 | 0.2941 | 0.1941 | 0.3580 | 0.1582 | 0.1018 |
| 2016 | 0.5713 | 0.2926 | 0.1931 | 0.3537 | 0.1571 | 0.1011 |
| 2017 | 0.5677 | 0.2910 | 0.1919 | 0.3480 | 0.1560 | 0.1004 |

Source: Authors' calculations.