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Working Paper

Cycles versus trends: The effects of economic growth on earnings in Bolivia

Development Research Working Paper Series, No. 08/2015

Provided in Cooperation with:

Institute for Advanced Development Studies (INESAD), La Paz

Suggested Citation: Muriel Hernández, Beatriz; Vera Cossio, Horacio (2015) : Cycles versus trends: The effects of economic growth on earnings in Bolivia, Development Research Working Paper Series, No. 08/2015, Institute for Advanced Development Studies (INESAD), La Paz

This Version is available at:

<https://hdl.handle.net/10419/129296>

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Institute for Advanced Development Studies



08/2015

**Cycles versus Trends:
The Effects of Economic Growth on Earnings in Bolivia ♥**

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Development Research Working Paper Series

08/2015

August 2015

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♥ A preliminary version of this paper was developed under auspices of the Project JACS SAM/CIDES-UMSA from the NCCR Norte-Sur.

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Abstract

This paper analyzes the effects of economic growth on labor earnings in Bolivia during 1999-2012. More precisely, we develop a labor market model to capture both cycle and trend effects of prices, and production on earnings, which is estimated econometrically using pseudo-panel data methods. The results show that labor earnings have had a pro-cyclical behavior. In particular, we find that, in the short run, an increase of 1% in prices or production explains an earnings rise of around 0.5%, while, in the long run, a production increase of 1% is associated with an earnings variation of 0.4%. Furthermore, we find that labor earnings growth by sector follows, to some extent, the economic performance of its corresponding sector, which responds to the sector segmentation characteristics in the Bolivian labor market.

Keywords: Bolivia, earnings, wages, economic growth, business cycle, pseudo-panel

JEL Classification: **E29, E32, J29, J39, J42**

I. Introduction

Bolivia has experienced two major business cycles turnovers between 1999 and 2012, passing from an economic recession stage to an expansion period. An important stylized fact related with this economic dynamics is that labor earnings had a pro-cyclical behavior: in the first cycle, around 1999 and 2003, real labor earnings had, on average, a negative annual rate of growth of -0.6%, while in the second period, between 2003 and 2012, this rate changed to 5.2%. In this regard, we notice that labor earnings evolution allowed a significant reduction on poverty during the last years, given that most of household incomes proceeds from these incomes (see, e.g., Uribe and Hernani, 2013; and Bernal *et al.* 2015).

However, the main concern about this fact arises on *how cyclical has been this labor earnings evolution*, and what would happen with the earnings growth in a possible recession period in the future. In this sense, we propose a simple, but novel, labor market model to determine the effects of economic performance over labor earnings through the inclusion of cyclical, and trend components of production, and prices. We include these variables by considering that the Bolivian labor market is segmented by sector where, in equilibrium, both worker and sector characteristics determine earnings.

From this model, we approach an earnings function, which is estimated using a pseudo-panel data with errors correction methods for the period 1999-2012, following Deaton (1985), Verbeek and Nijman (1992), Verbeek and Nijman (1993), and Inoue (2008), among others. We choose this econometric methodology because Bolivia does not have panel data on labor variables.

As far as we know, there are no studies for Bolivia, which analyze labor earnings with business cycle issues. However, we can find various empirical studies for other countries, which analyze the labor earnings procyclicality, and where some of them include theoretical models (see, e.g., Smith and Welch 1978, Bils 1985, Hart 2006, and Guvenen *et al.* 2014).

The empirical results support the pro-cyclical behavior of earnings during the period analyzed, which suggest that the positive earnings growth during the last economic expansion period may be reversed. In particular, we find that a 1% short-run increase in prices rises earnings by 0.5%, and a 1% growth in the cyclical component of production variable increases earnings by 0.52%. In addition, the estimated coefficient of the trend component of production shows that an increase of 1% in this variable rises earnings by 0.4%.

We also find a positive relationship of earnings with prices and production variables at the sector level. This result shows that earnings not only had a pro-cyclical behavior at the aggregate level, but also at the sector level, which in addition supports our segmented labor market model. In this regard, we highlight the mining-hydrocarbons sector, which had the highest growth in prices, earnings, and production during the economic expansion period, and where earnings variation was due mainly to the cyclical increase in prices.

The remainder of the paper proceeds as follows: Section II presents briefly the stylized facts on Bolivian economy, emphasizing the business cycles characteristics and their relationship with earnings. Section III shows the labor market model proposed. Section IV provides a detailed description of the data used as well as the econometric approach and estimations. Finally, Section VII presents the conclusions.

II. Stylized Facts

Bolivia has experienced two major business cycles turnovers from 1999 to 2012. In the first period, around 1999-2003, the economic growth presented low rates due to negative shocks such as, the financial crises of Argentina and Brazil (two main trade partners), the forced eradication of coca leaves, the fall of foreign direct investment, and the sociopolitical conflicts, among others (e.g., Chávez and Muriel, 2004; and Muriel and Jemio, 2011).

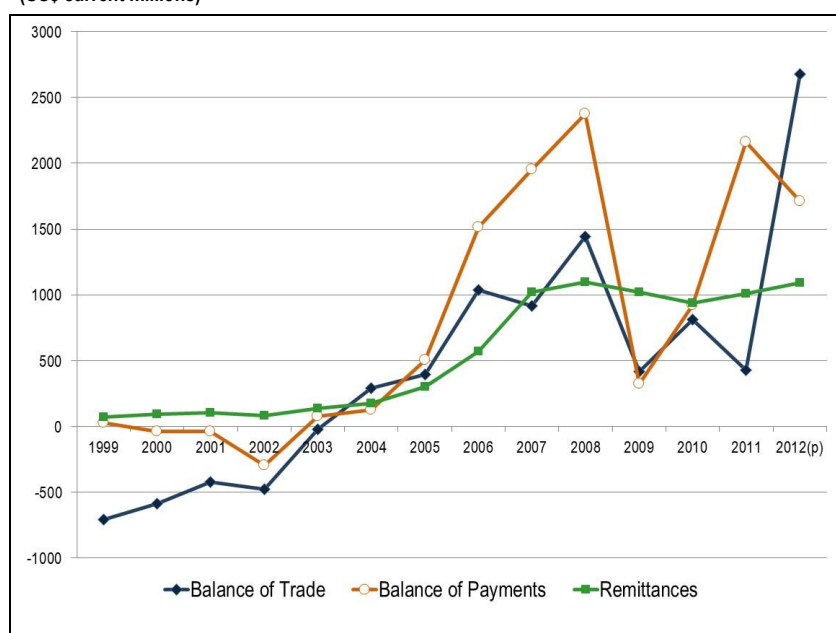
In the second cycle period, from 2003 to 2012, the economy grew faster, which responded to an extraordinary increase in monetary resources under a better sociopolitical context, which was the result of various shocks. Among some of them, we can highlight the sharp increase in many commodities exports - such as minerals, hydrocarbons and grains – according to the rise in international prices and consumption, as well as the increase of remittances.

Figure 1 presents the evolution of some selected macroeconomic indicators over 1999-2012, which reflects the money inflow to Bolivia. The Balance of Trade changed from a deficit position to a surplus one between 2002 and 2004, and it had a positive tendency of evolution until 2008, achieving a value of US\$ 1.444 million (8.6% of Gross Domestic Production, GDP). This performance has been a product of exports growth, which had an annual rate of 32.5% during 2003-2008. Between 2008 and 2009, trade surplus decreased given the negative shock of the financial crisis in developed countries. However, in 2012, it increased again because of the sharp growth of exports, with a rate of 34.8% during 2011-2012.

On the other hand, remittances' growth took off since 2004, and reached its highest level in 2008, with US\$ 1.097 million (6.5% of GDP). However, after 2008 remittances did not have any significant change, which may be also associated with the financial crisis in developed countries, given that Bolivian citizens have migrated mainly to Spain and United States (Organización Internacional para las Migraciones, 2012).

Figure 1 shows that the Balance of Payments performance followed, to some extent, the behavior of both the Balance of Trade and the Remittances. However, during 2011-2012 the surplus observed was also due to a major capital account surplus compared to the previous years.

Figure 1: Evolution of Selected Macroeconomic Indicators, 1999-2012
(US\$ current millions)



Source: Prepared by authors based on Bolivian Central Bank data.

Table 1 presents the evolution of selected real-side economic indicators resulting, in some way, from the money inflow. Government revenues and expenditures had a low performance between 1999 and 2003, as a consequence of the economic recession period. However, during 2003-2012, these revenues and expenditures grew fast, achieving annual rates of 12.4% and 9.0%, respectively.

It is important to highlight that, during 2005-2012, Government revenues growth were the result of not only the economic expansion, but also of the new tax policies with higher tax burdens on hydrocarbons and mining sectors (see, e.g., Aramayo, 2009; and Machicado, and Saravia, 2013). This policy made possible that government retain, in the country, a higher percentage of profits from foreign firms.

Table 1: Annual Growth of Selected Real-Side Economic Indicators, 1999-2012
(In percentage)

Indicators	1999-2003	2003-2012	1999-2012
Real Government Revenues	-2.9%	12.4%	7.5%
Real Government Expenditures	0.6%	9.0%	6.3%
Real Household Consumption	1.9%	4.2%	3.4%
Government Revenues/GDP	-3.0%	5.6%	2.9%
Government Expenditures/GDP	0.4%	2.4%	1.8%
Household consumption/GDP	-2.0%	-1.9%	-1.9%

Source: Prepared by authors based on data of both Bolivian Ministry of Economy and Finance, and Bolivian National Institute of Statistics.

Household consumption also grew at low rates between 1999 and 2003, and at high rates during 2003-2012, following the business cycles. Nevertheless, contrary to Government revenues and expenditures performance, this consumption grew at lower rates than the GDP.

Finally, Table 2 shows annual growth of real production and prices between the two periods of analysis, which are directly related with the business cycles. During 1999-2003, real production (measured by Gross Value of Production, GVP) grew at an annual growth of 2.5%, but during the expansion period, this rate increased to 4.8%.

Table 2: Average Annual Growth of Production, Prices and Average Earnings, 1999-2012

Economic Sector	1999-2003			2003-2012		
	Prices	Real GVP	Average Earnings ⁽¹⁾	Prices	Real GVP	Average Earnings ⁽¹⁾
Agriculture, forestry and fishing	2.9%	4.6%	16.0%	7.6%	2.4%	6.0%
Mining-hydrocarbons	15.6%	4.1%	4.6%	16.6%	8.0%	6.6%
Manufacturing	3.0%	3.4%	-0.6%	6.0%	4.4%	5.6%
Construction	4.4%	-4.9%	-7.1%	4.9%	8.9%	5.9%
Commerce, hotels and restaurants	2.5%	2.5%	-6.1%	7.1%	3.6%	5.3%
Transport and communication	3.6%	3.5%	-4.9%	3.2%	4.9%	2.9%
Banking and business services	1.8%	-1.3%	-10.6%	5.2%	4.7%	1.1%
Other sectors ⁽²⁾	5.0%	2.9%	0.3%	5.1%	4.8%	2.3%
Total	4.0%	2.5%	-0.6%	7.3%	4.8%	5.2%
Pearson correlation ⁽³⁾	0.29	0.64		0.57	0.25	

Source: Prepared by authors based on data of household surveys and national accounts from the Bolivian Institute of Statistics (INE).

Notes: ⁽¹⁾ Year 2003 corresponds to 2003 and 2004, given that household survey was collected for this period; ⁽²⁾ other sectors include electricity, natural gas and water supply, public administration, education, social and health services and other social services; and ⁽³⁾ correlations corresponds to production and prices with earnings at the sector level.

At the sector level, we can notice the mining-hydrocarbons sector, which had the highest GVP growth during 2003-2012 (8.0%). This increase reflects the effect of higher external demand for natural resources, which led to the export boom of these commodities in Bolivia. In contrast, the agriculture, forestry and fishing sectors had a low growth that may be due to weather effects, among others¹. The rest of the sectors had a higher growth rate of production in the second period, which, in some way, is due to the spread effects of the positive shocks experienced by the country.

The prices' rate of growth (measured by the GVP Implicit Deflator) also increased more during 2003-2012 (7.3%) compared to the first period (4.0%). In this case, the prices of all sectors grew faster in the second period, responding to the rising in external and internal demand.

Table 2 also presents real earnings growth over both periods. During 1999-2003, the annual rate of growth was negative (-0.6%), which could reflect the economic recession period. However, this rate reached 5.2% during the expansion period. Furthermore, comparing production and prices with earnings by sector, we find a positive correlation between the corresponding growth rates in both periods of analysis. This result suggests that sector performance was directly affected by its corresponding labor returns.

In short, the Bolivian stylized facts suggest that earnings had a pro-cyclical behavior during 1999-2012. In particular, during the expansion period, the mining-hydrocarbons sector grew fast, in production and prices, as a result of the extraordinary increase in foreign demand. This shock, associated with more remittances as well as more tax burdens on the mining-hydrocarbons sector, leads to extraordinary money inflow to the country. Then, these resources increased domestic demand, and consequently prices, and production in other sectors, which increased labor returns. However, earnings by sector grew at different rates, following, in some way, their corresponding sector economic performance, which may be associated to the segmentation problems in the labor market as documented by other authors (Mercado *et al.*, 2003; and Muriel, 2011). In this regards, sectors with higher production and prices growth would have experienced higher earnings growth.

III. A Labor Market Model for Bolivia

We analyze the relationship of earnings with prices and production variables by developing a labor market model. Following the stylized facts, we suppose that Bolivian

¹ However, in these sectors some products, as quinoa and soybean, had better performance (see, e.g, Medeiros, 2009, and Jemio 2015).

labor market is segmented in N economic sectors, which leads to multiple earnings equilibriums. The key for achieving this result remains on the assumption that workers have both sector specific skills (e.g., specific careers), and heterogeneous preferences of the working sector. In addition, we account for different skill levels for workers with similar specific skills and preferences, following the human capital theory (Becker 1993, and Mincer 1974).

Supply-side of the labor market

We follow Card (1995) analysis that Mincer earnings function can be derived from the utility maximization problem. In this regard, we suppose that a representative individual i ($i = 1, 2, \dots, I$) chooses the number of years of schooling (s_i) that maximizes her utility. For acquiring education, the individual gets credits that have to pay uniformly during her active life. Furthermore, we assume that some individuals prefer to acquire years of schooling related to specific skills needed in sector n ($n=1, 2, \dots, N$), as well as to work in this sector. We identify this group as I_n ($I_n = I_1, I_2, \dots, I_N, 0 < I_n < I, \sum_n I_n = I$).

With perfect foresight, the utility function ($U_{i \in I_n}$) of a representative individual $i \in I_n$ is determined by:

$$(1) \quad U_{i \in I_n} = \ln w_i(s_i) - h(s_i) - \tau_i$$

where U_i is continuous, concave and twice differentiable function in s_i ; $w_i(s_i)$ represents earnings associated to s_i ; $h(s_i)$ is a continuous twice differentiable convex function describing the education costs paid over time; and τ_i is a parameter equal to zero if individual i works in sector n , and positive otherwise. The parameter τ_i is a simple way of making explicit the disutility that an individual $i \in I_n$ has of working in a different sector than the one she would prefer². In addition, we assume that individual i always chooses education with specific skills associated with her sector of work preferences ($s_i = s_{in}$). Alternatively, we could consider that acquiring other kind of skills add to the education costs another disutility that is not an option for the individual (e.g., it makes the utility function negative given any feasible earnings).

The maximization problem leads to the following first order condition:

$$(2) \quad \frac{w'_i(s_i)}{w_i(s_i)} = h'(s_i)$$

² The literature discusses other approaches of worker tastes heterogeneities for working in different sectors (see, e.g., McFadden, 1981; Anderson *et al.*, 1992; and Bonhomme and Hospido, 2012).

which is a first-order differential equation in s_i . Thus, the Mincer earnings function for i is found considering that $h(s_i) = rs_i$ and resolving the differential equation:

$$(2') \quad w_i(s_i) = w_i(\bar{s}_i) e^{r(s_i - \bar{s}_i)}$$

where $r > 0$ is the discount rate, and \bar{s}_i is another possible level of education of individual i .

Demand-side of the labor market

We assume that for each sector n , there are K_n identical firms. A representative firm $k \in K_n$ maximizes its utility, which means – among other things – that it pays a wage $w_n(\bar{s})$, which equals the labor marginal productivity value. The variable \bar{s}_n represents the average years of schooling of workers that belong to I_n , where the productivity of the firm is determined by their specific skills.

In order to determine the wages, we consider a generic technology of production for each sector $f_n(A(\bar{s}_n), \mathbf{q}_n)$; where $f_n(\cdot)$ is continuous, concave and twice differentiable function, $A(\cdot)$ shows that only workers with specific skills can increase the productivity according to the Hicks neutral technology type, and \mathbf{q}_n is the vector row of inputs. Then, with perfect foresight, the firm maximization problem in a given period leads to the first order condition for employment (l):

$$(3) \quad w_n(\bar{s}_n) \Big|_{A=A(\bar{s}_n)} = p_n \frac{\partial f_n(A(\bar{s}_n), \mathbf{x}_k)}{\partial l_k} = \frac{p_n y_k}{l_k} \frac{\partial \ln y_k}{\partial \ln l_k} = \frac{p_n y_k}{l_k} \varepsilon_{ln}$$

where $y_k (= f_n(\cdot))$ is the production of the firm k , ε_{ln} is the employment-product elasticity, and p_n is the price (which is given for firm k).

We notice that if the infinitesimal increase in employment is relevant enough to change the average educations of specific skills from \bar{s}_n to $\bar{\bar{s}}_n$, $\bar{s}_n \neq \bar{\bar{s}}_n$ (i.e. this increase in employment belongs to I_n), then (3) should be redefined as

$$w_n(\cdot) = w_n(\bar{s}_n) \Big|_{A=A(\bar{s}_n)} + p_n \frac{\partial f_n(\cdot)}{\partial A(\bar{s}_n)} \frac{\partial A(\bar{s}_n)}{\partial \bar{s}_n} \frac{\partial \bar{s}_n}{\partial l_k} = w_n(\bar{\bar{s}}_n) \Big|_{A=A(\bar{\bar{s}}_n)}$$

Given that the firms in sector n are identical, we can aggregate expression (3) for all firms in order to find wages at the sector level:

$$(3') \quad w_n(\bar{s}_n) = \frac{p_n y_n}{L_n} \varepsilon_{ln}$$

where $L_n = \sum_{k \in K_n} l_k$.

Equilibrium

The equilibrium in the labor market depends on matching the specific skills between labor demand and labor supply. A perfect match implies then: $L_n = I_n \forall n \in N$. In this case, all individuals who choose specific skills for sector n in their corresponding education are hired by firms belonging to this sector, and these firms contract only workers that have education with their specific skills needs. Furthermore, wages are such that $\ln w_{in}(s_{in}) \geq \ln w_{in'}(s_{in'}) - \tau_i \forall i \in I_n, \forall n' \neq n \in N$ ($w_i(\cdot) = w_{in}(\cdot)$ and $s_i = s_{in}$ if i works in n).

In equilibrium, there are no labor mobility between sectors: individuals work in the sectors of their corresponding preferences and firms contract individuals that can increase their corresponding productivities. In this regard, we can match equations (2'), and (3) in the following way (see also Muriel, 2011):

$$(4) \quad w_{in}(s_{in}) = w_n(\bar{s}_n) e^{r(s_i - \bar{s}_n)} = \frac{p_n y_n}{L_n} \varepsilon_{ln} e^{r(s_{in} - \bar{s}_n)}$$

where $\bar{s}_{in} = \bar{s}_n$, and $w_{in}(\cdot) = w_n(\cdot)$.

An imperfect match implies $\ln w_{in}(s_{in}) < \ln w_{in'}(s_{in'}) - \tau_i \forall i \in I_n$ in some \hat{N} ($< N$) sectors. Then, individuals who prefer to work in sectors \hat{N} are willing to offer their work in other sectors \check{N} ($\hat{N} + \check{N} \leq N$) because the disutility of working in these sectors is compensated by higher wages. In this sense, multiple wage equilibriums can be obtained, depending on the heterogeneities in labor supply and labor demand that we considered in the model.

In addition, we notice that an individual $i \in I_n$ with s_i years of schooling, working in sector n' receives also a wage expressed by equation (4), with the difference that $p_{n'} \frac{\partial f_{n'}(\cdot)}{\partial A(\bar{s}_{n'})} \frac{\partial A(\bar{s}_{n'})}{\partial \bar{s}_{n'}} \frac{\partial \bar{s}_{n'}}{\partial l_{kn'}} = 0 \forall k \in K_{n'}$ for an infinitesimal increase of employment of individual $i \in I_n$.

Cycle versus Trend Wage Determinants

In order to separate the cycle versus the trend components of both prices and production, we assume the following. First, we consider that the prices have a common trend p_{TD} , where the subscript TD refers to trend. In a given period t ($t = 1, 2, \dots, T$), this price allows to find both real wages and the cyclical component of prices for any sector n as: $\bar{w}_{in,t}(s_i) = w_{in,t}(s_i) / p_{TD,t}$, and $p_{Cn,t} = p_{n,t} / p_{TD,t}$, respectively, where de subscript C refers to cycle, and t to period.

Second, following Espasa and Cancelo (1993), among others, we assume that production for a sector n can be broken down into its trend and cyclical components as: $y_{n,t} = y_{Cn,t} \times y_{TDn,t}$.

We replace the cyclical and trend components described above in (4), take logarithms, and approach it to a preliminary version of the earnings equation for empirical estimation:

$$(5) \quad \ln \tilde{w}_{in,t} = \beta_n + \beta_1 \ln p_{Cn,t} + \beta_2 \ln y_{Cn,t} + \beta_3 \ln y_{TDn,t} + \beta_4 L_{n,t} + r(s_{in,t} - \bar{s}_{n,t}) + \varepsilon_{i,t}$$

where $\varepsilon_{i,t}$ is the error term *i.i.d.* (independent and identically distributed), and the betas are the parameters to be estimated.

Finally, from expression (5), we can analyze the relative cycle versus trend effects on earnings in a given time as well as over time. First, we aggregate all workers by sector and redefine (5) as:

$$(6) \quad \ln \tilde{w}_{n,t} = \hat{\beta}_n + \hat{\beta}_1 \ln p_{Cn,t} + \hat{\beta}_2 \ln y_{Cn,t} + \hat{\beta}_3 \ln y_{TDn,t} + \hat{\beta}_4 \ln L_{n,t} + \varepsilon_{n,t}$$

where, $\ln \tilde{w}_{n,t} = \frac{\sum_i \ln \tilde{w}_{in,t}}{L_{n,t}}$, $\ln \varepsilon_{n,t} = \frac{\sum_i \varepsilon_{i,t}}{L_{n,t}}$, and the circumflexes over the betas refers to

the estimates of these parameters.

In addition, from expression (6) we can analyze the relative relevance of variation of each explicative variable on earnings change over time as follows:

$$(7) \quad 1 = \frac{\hat{\beta}_1 \Delta \ln p_{Cn,t} + \hat{\beta}_2 \Delta \ln y_{Cn,t}}{\Delta \ln \tilde{w}_{n,t}} + \hat{\beta}_3 \frac{\Delta \ln y_{TDn,t}}{\Delta \ln \tilde{w}_{n,t}} + \hat{\beta}_4 \frac{\Delta \ln L_{n,t}}{\Delta \ln \tilde{w}_{n,t}} + \frac{\Delta \varepsilon_{n,t}}{\Delta \ln \tilde{w}_{n,t}}$$

where Δ refers to discrete changes in variables between two consecutive periods (t and $t-1$). Expression $\frac{\hat{\beta}_1 \Delta \ln p_{Cn,t} + \hat{\beta}_2 \Delta \ln y_{Cn,t}}{\Delta \ln \tilde{w}_{n,t}}$ approaches earnings change due to cyclical

components, which are associated with business cycles. The term $\hat{\beta}_3 \frac{\Delta \ln y_{TDn,t}}{\Delta \ln \tilde{w}_{n,t}}$ captures

earnings change derived from the production trend change, which are associated with changes in labor productivity. Expression $\hat{\beta}_4 \frac{\Delta \ln L_{n,t}}{\Delta \ln \tilde{w}_{n,t}}$ shows the effects of employment-

labor supply change in sector n on earnings change; and the last component, $\frac{\Delta \varepsilon_{n,t}}{\Delta \ln \tilde{w}_{n,t}}$,

represents unknown variables explaining earnings change.

IV. Empirical Analysis

IV.1. Econometric Approach

Bolivia does not have panel data on labor variables in order to estimate equation (5). In this sense, we construct a pseudo panel model for earnings using Bolivian household surveys. This model can be expressed in standard form as follows:

$$(8) \quad z_{h,t} = \mathbf{x}_{h,t}^* \boldsymbol{\beta} + \theta_h + \gamma_t + \varepsilon_{h,t}$$

$$\mathbf{x}_{h,t} = \mathbf{x}_{h,t}^* + \mathbf{v}_{h,t}$$

$$\mathbf{v}_{h,t} \sim N(\mathbf{0}, \boldsymbol{\Sigma}_{vv}); \varepsilon_{h,t} \sim N(0, \sigma_\varepsilon^2); E[\mathbf{x}_{h,t}^* | \mathbf{v}_{h,t}] = E[\varepsilon_{h,t} | \mathbf{v}_{h,t}] = \mathbf{0}$$

where h subscript refers to cohort ($h=1, 2, \dots, H$) and t subscript refers to survey year ($t=1, 2, \dots, T$); $z_{h,t} = \frac{\sum_{i \in h} \ln \tilde{w}_{i,t}}{l_{h,t}}$; $l_{h,t}$ represents employment in cohort h , $\mathbf{x}_{h,t}^*$ is a column vector ($J \times 1$) grouping J independent variables (drawn from population) with a representative element variable $x_{h,t}^* = \frac{\sum_{i \in h} x_{i,t}^*}{l_{h,t}}$; $\boldsymbol{\beta}$ is a column vector grouping the coefficients; θ_h is a constant that captures cohort (and includes β_n) fixed effects; γ_t is a parameter that captures time fixed effects; and $\varepsilon_{h,t}$ is the error term.

We follow Deaton (1985), Verbeek and Nijman (1992), and Verbeek and Nijman (1993) to explicitly consider that, unlike cohorts derived from census data, the calculus of each variable $x_{h,t}^*$ using sampling data has measurement errors. These errors are described in the second expression of (8), where each $x_{h,t}^*$ (obtained from sampling data) is equal to $x_{h,t}^*$ plus an error term, $v_{h,t}$. Last, the third expression of (8) shows the distribution properties of $\varepsilon_{h,t}$, and $v_{h,t}$, as well as their independency with the corresponding regressors.

Furthermore, we notice that θ_h and γ_t may be correlated with some $x_{h,t}^*$ variables. This is because, as we explain below, we determine cohorts by sector, years of schooling and age, which are related with independent variables considered in the model. In this regard, we use the following approach that isolates fixed effects from surveys and cohorts (see, e.g., Hsiao, 2003):

$$(9) \quad \mathbf{Qz} = \mathbf{QX}^* \boldsymbol{\beta} + \mathbf{Q}\theta + \mathbf{Q}\gamma + \mathbf{Q}\varepsilon = \mathbf{QX}^* \boldsymbol{\beta} + \mathbf{Q}\varepsilon$$

$$\begin{aligned}\tilde{\mathbf{z}} &= \tilde{\mathbf{X}}^* \boldsymbol{\beta} + \boldsymbol{\varepsilon}, \tilde{\mathbf{z}} = \mathbf{Q} \mathbf{z}^*, \tilde{\mathbf{X}}^* = \mathbf{Q} \mathbf{X}^*, \tilde{\boldsymbol{\varepsilon}} = \mathbf{Q} \boldsymbol{\varepsilon} \\ \mathbf{Q}_{HT \times HT} &= \mathbf{I}_{HT} - \mathbf{I}_H \otimes \frac{1}{T} \mathbf{0}_{T \times 1} \mathbf{0}_{T \times 1}' - \frac{1}{H} \mathbf{0}_{H \times 1} \mathbf{0}_{H \times 1}' \otimes \mathbf{I}_T + \frac{1}{HT} \mathbf{0}_{HT \times 1} \mathbf{0}_{HT \times 1}'\end{aligned}$$

where we staked data over H cohorts and T periods corresponding to surveys. \mathbf{z} , $\boldsymbol{\theta}$, $\boldsymbol{\gamma}$, and $\boldsymbol{\varepsilon}$ are column vectors ($HT \times 1$) grouping the $z_{h,t}$, θ_h , γ_t and $\varepsilon_{h,t}$ elements respectively; \mathbf{X}^* is the matrix ($HT \times J$) grouping all independent variables observations; \mathbf{I} represents the identity matrix, \mathbf{o} a is column vector with all elements equal to one; and \otimes denotes the Kronecker product. Last, the third expression in (9) determines the matrix \mathbf{Q} , where the subscripts highlights the dimension of vectors and matrices.

A first approach for estimating the parameters in (9) is using OLS (Ordinary Least Squares) method; however, we notice that:

$$\begin{aligned}(10) \text{plim } \hat{\boldsymbol{\beta}} &= (\text{plim } N^{-1} \tilde{\mathbf{X}}' \tilde{\mathbf{X}})^{-1} (\text{plim } N^{-1} \tilde{\mathbf{X}}' \tilde{\mathbf{z}}) = (\boldsymbol{\Sigma}_{\tilde{\mathbf{X}} \tilde{\mathbf{X}}})^{-1} (\boldsymbol{\Sigma}_{\tilde{\mathbf{X}} \tilde{\mathbf{z}}} - \boldsymbol{\Sigma}_{\tilde{\mathbf{X}} \tilde{\boldsymbol{\varepsilon}}}) \boldsymbol{\beta} \\ &\Rightarrow \text{plim } \hat{\boldsymbol{\beta}} = \boldsymbol{\beta} - (\boldsymbol{\Sigma}_{\tilde{\mathbf{X}} \tilde{\boldsymbol{\varepsilon}}} + \boldsymbol{\Sigma}_{\tilde{\boldsymbol{\varepsilon}} \tilde{\boldsymbol{\varepsilon}}})^{-1} \boldsymbol{\Sigma}_{\tilde{\boldsymbol{\varepsilon}} \tilde{\mathbf{X}}} \boldsymbol{\beta}\end{aligned}$$

The literature suggest some ways to solve this inconsistency problem, such as inverse regressions, identification by instrumental variables, identification trough restrictions on moments and estimations by intervals (see Cameron and Trivedi (2005) for a survey). We follow Deaton (1985), and Verbeek and Nijman (1992, 1993) by using replicated data, which consists in calculating estimators based on surveys, where:

$$\text{plim } \hat{\boldsymbol{\beta}} = \text{plim} \left[(\tilde{\mathbf{X}}' \tilde{\mathbf{X}} - \hat{\boldsymbol{\Sigma}}_{\tilde{\boldsymbol{\varepsilon}} \tilde{\boldsymbol{\varepsilon}}})^{-1} (\tilde{\mathbf{X}}' \tilde{\mathbf{y}}) \right] = (\boldsymbol{\Sigma}_{\tilde{\mathbf{X}} \tilde{\mathbf{X}}} + \boldsymbol{\Sigma}_{\tilde{\boldsymbol{\varepsilon}} \tilde{\boldsymbol{\varepsilon}}} - \boldsymbol{\Sigma}_{\tilde{\mathbf{X}} \tilde{\boldsymbol{\varepsilon}}})^{-1} (\boldsymbol{\Sigma}_{\tilde{\mathbf{X}} \tilde{\boldsymbol{\varepsilon}}} \boldsymbol{\beta}) = \boldsymbol{\beta}.$$

The $\boldsymbol{\beta}$ estimator is the measure of the adjusted error estimator, which is consistent for large samples:

$$(10') \hat{\boldsymbol{\beta}} = \left(\tilde{\mathbf{X}}' \boldsymbol{\Pi} \tilde{\mathbf{X}} - \frac{(T-1)}{T} \hat{\boldsymbol{\Sigma}}_{\tilde{\boldsymbol{\varepsilon}} \tilde{\boldsymbol{\varepsilon}}} \right)^{-1} (\tilde{\mathbf{X}}' \boldsymbol{\Pi} \tilde{\mathbf{z}})$$

and

$$\begin{aligned}\hat{\mathbf{V}}(\boldsymbol{\beta}) &= \frac{1}{HT} \left(\tilde{\mathbf{X}}' \boldsymbol{\Pi} \tilde{\mathbf{X}} - \frac{(T-1)}{T} \hat{\boldsymbol{\Sigma}}_{\tilde{\boldsymbol{\varepsilon}} \tilde{\boldsymbol{\varepsilon}}} \right)^{-1} \\ &\times \left((\tilde{\mathbf{X}}' \boldsymbol{\Pi} \tilde{\mathbf{X}} * \tilde{\boldsymbol{\varepsilon}}' \boldsymbol{\Pi} \tilde{\boldsymbol{\varepsilon}}) + \tilde{\mathbf{X}}' \boldsymbol{\Pi} \tilde{\boldsymbol{\varepsilon}} \tilde{\boldsymbol{\varepsilon}}' \boldsymbol{\Pi} \tilde{\mathbf{X}} \right) \left(\tilde{\mathbf{X}}' \boldsymbol{\Pi} \tilde{\mathbf{X}} - \frac{(T-1)}{T} \hat{\boldsymbol{\Sigma}}_{\tilde{\boldsymbol{\varepsilon}} \tilde{\boldsymbol{\varepsilon}}} \right)^{-1}\end{aligned}$$

where $\boldsymbol{\Pi}$ is the diagonal matrix ($HT \times HT$) of proportional weights. We follow Inoue (2005) for constructing this matrix, where each cohort is weighted as the proportion of

workers belonging to this cohort over all observations: $\pi_{ht} = \frac{\sum_{ieh} f_{iht}}{\sum_{t=1}^T \sum_{h=1}^H \sum_{ieh} f_{iht}}$. As we show

below, each f_{iht} is the frequency weight provided in the surveys for individual observation i .

Since labor supply is an endogenous variable, we use a 2SLS (Two Stage Least Squares) estimator. We replace $\tilde{\mathbf{X}}'$ with the estimate in equation (11), where \mathbf{M} is a matrix of instruments with dimensions of HT rows by J columns. The error correction is made in the first stage estimation:

$$(11) \quad \hat{\tilde{\mathbf{X}}}' = \left(\mathbf{M}' \mathbf{I} \mathbf{M} - \frac{T-1}{T} \boldsymbol{\Sigma}_{\tilde{\mathbf{w}}} \right)^{-1} \mathbf{M}' \mathbf{I} \tilde{\mathbf{X}}$$

IV.2. Data Description

The information required for empirically analyzing the labor market model is obtained from two main sources developed by the Bolivian Institute of Statistics (INE). The first source is the Bolivian household surveys for years with information (1999, 2000, 2001, 2002, 2003-04, 2005, 2006, 2007, 2008, 2009, 2011, and 2012), and the second source is National Accounts.

Cohort Variables

We build cohorts considering workers that in the 1999 household survey had 18 years old or more, and whose main occupation sector is not classified as “services of extraterritorial organizations.” We exclude workers from this sector because the Bolivian National Accounts do not include this activity as part of domestic production.

Next, we notice that cohorts’ classification is, in general, subjective. In this regard, we determine cohorts by taking into account both the number of observations, and the representativeness within and between each survey to construct reliable weights (Inoue, 2008). In addition, we try to maintain symmetry over the number of observations between cohorts, and over time, given the condition for consistency: $H \rightarrow \infty$, for a fixed numbers of cohort, which guaranties that $\sum_{ieh} l_{in} \rightarrow \infty$ (Verbeek, 2008).

We then specify 65 cohorts from the 12 household surveys. These cohorts of workers are categorized by three attributes: main occupation sector, age and years of schooling. We choose these variables to be consistent with both the hypothesis of sector segmentation in the labor market, and to better control for differences in labor productivity.

We consider eight economic sectors according to Bolivian Classification of Economic Activities (CAEB for its acronym in Spanish). These are: 1st agriculture, forestry and fishing, 2nd mining-hydrocarbons, 3rd manufacturing, 4th construction, 5th commerce, hotels and restaurants, 6th transport and communication, 7th banking and business services, and 8th electricity, natural gas and water supply, public administration, education, social and health services and other social services. The number of observations in each cohort by sector and survey is summarized by year in Table 3.

Table 3: Observations by Economic Sector and Survey Year

Sector	1999	2000	2001	2002	2003-04	2005	2006	2007	2008	2009	2011	2012	Total
1 st Sector	1,166	1,779	2,663	2,026	1,735	1,442	942	1,013	1,281	1,196	2,203	1,920	19,366
2 nd Sector	117	181	186	198	295	145	80	110	57	60	198	174	1,801
3 rd Sector	455	627	679	795	1,502	519	582	549	461	468	907	892	8,436
4 th Sector	268	392	467	519	1,009	395	346	391	320	331	731	679	5,848
5 th Sector	858	1,213	1,229	1,474	2,979	923	1,005	1,005	903	918	1,997	2,053	16,557
6 th Sector	257	328	434	427	852	350	364	372	301	335	725	699	5,444
7 th Sector	127	190	224	190	518	131	241	200	216	205	405	457	3,104
8 th Sector	754	1,081	1,247	1,356	2,855	899	1,105	1,102	873	901	2,008	1,799	15,980
Total	4,002	5,791	7,129	6,985	11,745	4,804	4,665	4,742	4,412	4,414	9,174	8,673	76,536

Source: Prepared by authors based on data of Bolivian household surveys.

Note: Sector are: 1st agriculture, forestry and fishing, 2nd mining-hydrocarbons, 3rd manufacturing, 4th construction, 5th commerce, hotels and restaurants, 6th transport and communication, 7th banking and business services, and 8th electricity, natural gas and water supply, public administration, education, social and health services and other social services.

The previous Table shows that each cohort has different number of observations, being the minimum size 57, which corresponds to the second sector in 2008. This group is our benchmark for the minimum size of cohorts³.

Furthermore, we take into account the 2006 household survey as the middle point for cohort representativeness for the period analyzed. We divide observations in each sector by the cohort minimum size (57) in order to determine suitable quintiles in each sector. In this regard, we divide the first sector by deciles, the third sector by quartiles, the fourth and the sixth by their respective mediums, the fifth by octiles, and eighth by sextiles. The second and the seventh sector observations are not divided because these observations are few.

³ We do not use birth dates as a criterion to separate cohorts because years' classification should be fixed.

The last criterion for cohort identification is years of schooling. We notice that education levels are heterogeneous between sectors, which do not allow having a standard division. However, median of years of schooling is lower for cohorts of older workers than for younger workers, which gives some homogeneity within cohorts, and heterogeneity between them. For instance, in the first sector (agriculture, forestry and fishing) the oldest workers cohort has a median of zero years of education, while the youngest workers cohort has a median of five years. In this regard, we divide the cohorts, already determined by sector and age, by the median of years of schooling within each cohort. As a result, we have 65 cohorts per year, with 780 observations considering the 12 household surveys.

The variables constructed by cohort using the household surveys are:

- Main occupation earnings in logarithms, $\ln \tilde{w}_{in,t}$, calculated following INE (2002) methodology. In the case of unsalaried workers, it corresponds to the net profit by deducting all declared costs (payment of salaries, intermediate consumption, service expenses, tax payments and other contributions) from the gross income. In the case of salaried workers, it is equal to the basic salary minus taxes and contributions plus all the additional monetary and nonmonetary payments (overtime, bonuses, food, transport, etc.). We measure earnings in working hours, and divide by the implicit deflator of household consumption to obtain real values.
- The gap between cohort and sector specific skills education, $s_{hn,t} - \bar{s}_{n,t}$, which is approached by the workers cohort mean of years of schooling less workers sector mean of years of schooling.
- The gap between the workers cohort mean of experience less workers sector mean of experience, $e_{hn,t} - \bar{e}_{n,t}$, and squared experience, $c(e_{hn,t}^2 - \bar{e}_{n,t}^2)$, which are included in order to control for additional differences in labor productivity, following usual regressors considered in supply-side earnings regressions. Experience is measured as age minus years of schooling minus six.

- The weights, $\pi_{ht} = \frac{\sum_{i \in h} f_{iht}}{\sum_{t=1}^T \sum_{h=1}^H \sum_{i \in h} f_{iht}}$, which are approached by the weights of each

observation calculated by INE, and found in the surveys.

Table 4 presents relevant summary statistics of variables by cohort. Average earnings by hour decreases between 1999 and 2003-05, but increases in subsequent years. Average years of schooling presents an evolution similar to the previous variable, and achieves an average of 8.9 years in 2012. Years of experience increases during all the period analyzed following the changes of age cohorts over time. In addition, the Pearson coefficient of variation estimated by year shows a relatively low heterogeneity in observations.

Table 4: Summary Statistics, Bolivian Household Surveys 1999-2012

	1999	2000	2001	2002	2003-04	2005	2006	2007	2008	2009	2011	2012
<i>Earnings by hour (in Bs of 1990)</i>												
Mean	2.47	2.38	2.39	2.37	2.40	2.59	2.74	2.47	2.67	2.79	2.97	3.04
Minimum	0.22	0.27	0.39	0.54	0.34	0.41	0.33	0.19	0.37	0.60	0.42	0.63
Maximum	7.51	7.61	8.52	7.80	7.67	7.49	7.96	7.33	7.34	7.09	6.62	7.67
Standard Deviation	1.84	1.73	1.65	1.67	1.56	1.67	1.80	1.48	1.52	1.47	1.30	1.49
Coefficient of Variation	0.74	0.73	0.69	0.70	0.65	0.64	0.66	0.60	0.57	0.53	0.44	0.49
<i>Years of schooling</i>												
Mean	7.84	8.15	8.05	7.85	7.69	8.18	8.59	8.71	8.42	8.68	8.78	8.93
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	16.50	16.57	16.83	16.75	16.77	17.07	16.82	16.83	16.88	16.79	16.97	17.16
Standard Deviation	4.68	4.47	4.52	4.46	4.42	4.68	4.87	4.80	4.77	4.85	4.81	4.80
Coefficient of Variation	0.60	0.55	0.56	0.57	0.57	0.57	0.57	0.55	0.57	0.56	0.55	0.54
<i>Years of experience</i>												
Mean	25.89	25.04	25.85	26.39	27.07	28.69	28.13	29.10	30.18	30.23	31.41	32.08
Minimum	1.34	2.07	2.95	4.01	4.90	6.02	6.49	7.68	8.42	9.80	11.49	12.29
Maximum	65.48	65.25	66.13	67.15	68.86	69.28	69.40	70.50	72.70	72.26	73.90	73.87
Standard Deviation	15.59	14.77	15.60	14.93	15.13	15.42	14.92	14.94	14.67	14.64	13.98	13.67
Coefficient of Variation	0.60	0.59	0.60	0.57	0.56	0.54	0.53	0.51	0.49	0.48	0.44	0.43

Production and Price Variables

We estimate production and price variables by sector and year using Bolivian National Accounts, which can be harmonized with the CAEB classification. We divide prices by the implicit deflator of household consumption to obtain the corresponding cyclical component ($p_{Cn,t}$).

We approach production by the gross value of production (GVP), which is measured at 1990 prices. We choose this variable, instead of gross domestic production (GDP), because of both it is better measured from sales data, and it has richer information by including intermediate consumption.

We separate cyclical versus trend components of production by sector using the Hodrick-Prescott filter (Hodrick and Prescott, 1997). We have information of GVP from 1988 to 2012, and of gross value added (GVA) harmonized by ECLAC ((Economic Commission for Latin America and the Caribbean) from 1970 to 2012. In this regard, we estimate GVP from 1970 to 1987 from GVA and intermediate consumption (IC) to have more reliable

variables of production:
$$GVP_{n,t} = \frac{GVA_{n,t}}{\sum IC_{n'n,1990}^{1 - \frac{n}{GVP_{n,1990}}}}$$
, where the year 1990 in the formula

corresponds to the base year of the current National Accounts.

Once obtained the GVP series by sector from 1970 to 2012, we apply the Hodrick-Prescott filter using the Ravn-Uhlig rules, who recommend a value of λ equal to 6.25 for annual data (Ravn and Uhlig, 2002).

Finally, we use the data of employment-labor supply by sector (L_n) constructed by the INESAD Foundation, which estimates the variable using both the National Accounts and the Census of 1992, 2002, and 2012. This information is available in the EMINPRO-INESAD database, including the corresponding technical specification, in the following webpage: www.inesad.edu.bo/eminpro.

Table 5 shows Pearson correlation coefficients of the variables under analysis.

Table 5: Pearson Correlation of Variables, 1999-2012

Variables	$\ln\tilde{w}_{hn,t}$	$\ln p_{Cn,t}$	$\ln y_{Cn,t}$	$\ln y_{TDn,t}$	$L_{n,t}$	$s_{hn,t} - \bar{s}_{n,t}$	$e_{hn,t} - \bar{e}_{n,t}$	$e_{hn,t}^2 - \bar{e}_{n,t}^2$
$\ln\tilde{w}_{hn,t}$	1.000							
$\ln p_{Cn,t}$	0.452	1.000						
$\ln y_{Cn,t}$	0.083	0.085	1.000					
$\ln y_{TDn,t}$	0.098	-0.031	0.096	1.000				
$L_{n,t}$	-0.621	-0.484	0.051	0.083	1.000			
$s_{hn,t} - \bar{s}_{n,t}$	0.347	0.000	0.000	0.000	0.000	1.000		
$e_{hn,t} - \bar{e}_{n,t}$	-0.201	0.000	0.000	0.000	0.000	-0.589	1.000	
$e_{hn,t}^2 - \bar{e}_{n,t}^2$	-0.231	0.000	0.000	0.000	0.000	-0.554	0.961	1.000

Source: Prepared by authors based on data of the Bolivian Institute of Statistics (INE).

IV.3. Econometric Results

Table 6 shows the pseudo-panel econometric results of the Bolivian labor market model described above. We develop four regressions in order to evaluate differences between the inclusion of errors correction (expression $\frac{(T-1)}{T}\hat{\Sigma}_{\tilde{v}\tilde{v}}$ in (10')), as well as changes in estimations by instrumental variables using 2SLS, where the instrument of employment is the same variable but with one lag. In general, the coefficients estimated show the expected signs in all cases, being consistent with equations (4) and (5).

In both groups of regressions (with and without errors correction), the consideration of instrumental variables generates coefficients of L_n that are statistically different (i.e., comparing regressions (1) with (2), and (3) with and (4)). Furthermore, we find discrepancies in the estimated coefficients between regressions with and without errors correction, which show the need to include these errors econometrically in order to generate consistent estimators. In this regard, regression (4), in Table 6, is our final selection.

In regression (4), the significance of the coefficients of the cyclical components of prices and production shows the pro-cyclical behavior of earnings during 1999-2012. In particular, a 1% short-run increase in prices is associated to a rise in earnings by 0.5%, and a 1% growth in cyclical production increases earnings by 0.52%.

The coefficient of the trend component of production is also relevant for explaining earnings over time. In this sense, an increase of 1% in this variable is associated with a rise in earnings of 0.4%. Furthermore, differences in productivity accounting for cohort

characteristics shows that our *years of schooling* measure ($s_{hn,t} - \bar{s}_{n,t}$) has a positive effect on earnings, and *experience* ($e_{hn,t} - \bar{e}_{n,t}$) also presents a positive impact with decreasing marginal returns ($e_{hn,t}^2 - \bar{e}_{n,t}^2$). Last, the employment-earnings elasticity shows that an increase of 1% in employment is associated with a fall of 0.5% in earnings.

Table 6: Earnings ($\ln \tilde{w}_{hn,t}$) Regressions, 1999-2012

Variables	Without Errors Correction				With Errors Correction			
	(1)		(2)		(3)		(4)	
	Fixed Effect		IV-Fixed Effect		Fixed Effect		IV-Fixed Effect	
	Coefficient	P value	Coefficient	P value	Coefficient	P value	Coefficient	P value
$\ln p_{Cn,t}$	0.516	0.000	0.506	0.000	0.502	0.000	0.504	0.000
$\ln y_{Cn,t}$	0.872	0.012	0.930	0.007	0.868	0.017	0.517	0.118
$\ln y_{TDn,t}$	0.281	0.070	0.372	0.023	0.315	0.055	0.404	0.019
$L_{n,t(t-1)}$	-0.268	0.008	-0.377	0.002	-0.291	0.009	-0.470	0.000
$s_{hn,t} - \bar{s}_{n,t}$	0.062	0.000	0.065	0.000	0.101	0.000	0.068	0.000
$e_{hn,t} - \bar{e}_{n,t}$	0.015	0.027	0.016	0.011	0.020	0.029	0.019	0.001
$e_{hn,t}^2 - \bar{e}_{n,t}^2$	-1.91E-04	0.002	-1.93E-04	0.004	-2.14E-04	0.004	-1.97E-04	0.004
Observations	780		780		780		780	

Source: Estimated by authors based on data of the Bolivian Institute of Statistics (INE).

Note: IV means instrumental variables.

Figure 2 shows the annual variation of earnings, as well as the relative importance of prices and production variation on this variable for selected sectors, according to equation (7).⁴ Just as in the case of the stylized facts, we highlight the high earnings growth of the mining-hydrocarbons sector during the economic expansion period, which has been mainly associated with the cyclical increase in prices. In particular, during 2003 and 2007, we estimate that prices variation accounted for 49.3% of the increase in earnings, while trend production explained 19.5%.

In contrast, for the manufacturing sector, earnings variation is lower and less volatile compared to the previous sector. In this case, we can highlight the rise of the trend component of production, which had a positive effect on earnings variation in all the analyzed years, explaining around the 9.8% of this rise between 1999 and 2012.⁵ The

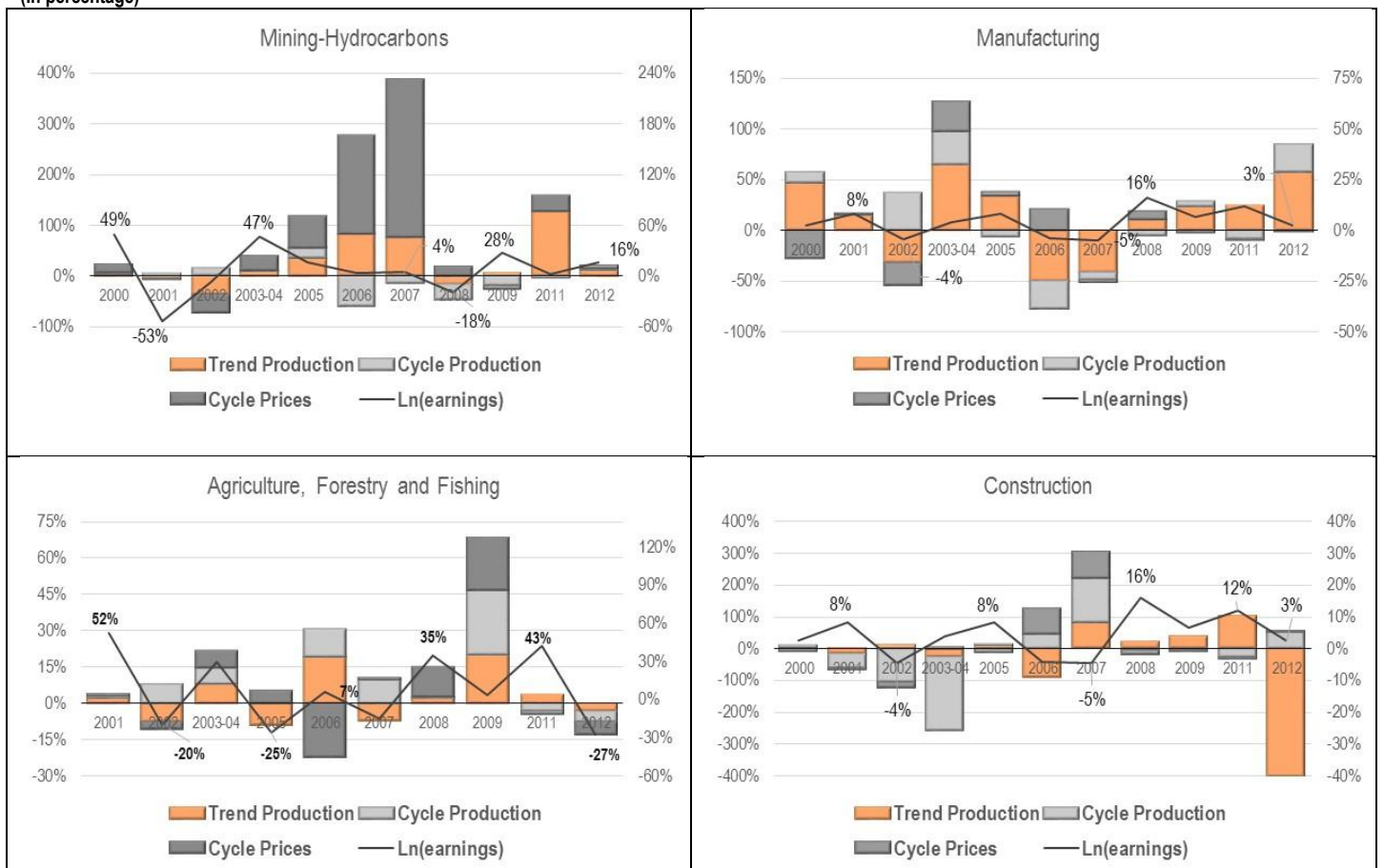
⁴ Table A.1. in Annex presents this information for all sectors.

⁵ We notice that in 2002, 2006, and 2007 the earnings variations are negative, but the trend production variations are positive. In this regard, the division between these variables results in a negative value according to equation (7), meaning a positive contribution of trend component of production on earnings.

cycle variables present irregular contributions over earnings variations; however, they had a relatively important positive impact in 2003-04 and 2012.

In the Agriculture, forestry and fishing sectors, earnings variation presents a high volatility, with negative and positive values over time. The positive effect of the cyclical component of prices becomes relevant in 2002, 2003-04, 2008, 2009 and 2012, which in the economic expansion period may be associated, to some extent, to the international prices growth of some foods. In the case of the production variable, its cyclical component has a positive and important impact in 2003-04, 2006, 2009 and 2012, while its trend component has a positive effect in all the period analyzed.

Figure 2: Evolution of Earnings, and Prices and Production Components over Earnings, 1999-2012
(In percentage)



Source: Prepared by authors based on data of the Bolivian Institute of Statistics (INE).

Note: We exclude the year 2000 in agriculture, forestry and fishing sectors because the relative participation of variables was very high, making difficult the analysis for the following years.

Finally, in Figure 2 we present the construction sector because it has experienced a significant growth during the last years, following the economic expansion period. This

growth is associated with earnings variation, which had positive values during 2008-2012. However, during this period the cycle variables had a positive effect only in 2012, while the trend component in production had positive impact during 2008-2011, but a negative effect in 2012.

V. Conclusions

This article analyzes the effects of economic growth on labor earnings. Initially, we discuss some stylized facts of Bolivian economic growth associated with two major business cycles turnovers from 1999 to 2012. In the first cycle, around 1999-2003, economic growth presented low rates due to some negative shocks. However, in the second period, from 2003 to 2012, the economy grew fast, essentially due to the sharp increase in commodities exports as well as the increase of remittances.

Next, we link these economic dynamics with the real labor earnings evolution, finding two interesting facts. Firstly, we show that real labor earnings have a pro-cyclical behavior. In the first cycle, this variable had, on average, a negative annual rate of growth of -0.6%, while in the second period this rate changed to 5.2%. Second, we observe that, at the sector level, labor earnings growth was directly affected by the corresponding prices and production sectors growth. This suggests the existence of sector segmentation problems in the Bolivian labor market.

In this regard, we develop a simple, but novel, labor market model, considering segmentation by sector. This segmentation arises from the assumption that each sector requires specific skills provided by years of schooling in order to increase their productivities. Furthermore, individuals have heterogeneous preferences on acquiring these specific skills as well as on working in a given sector. The result is a new earnings equation where we include, among other usual variables considered, cyclical and trend components of prices and production at the sector level.

From this theoretical model, we derive an econometric model, which is estimated using a pseudo-panel data with errors correction methods for the period 1999-2012, following Deaton (1985), Verbeek and Nijman (1992), Verbeek and Nijman (1993), and Inoue (2008). We choose this econometric methodology because Bolivia does not have panel data on labor variables.

The empirical analysis shows that prices and production components are fundamental factors for explaining labor earnings. These results support the pro-cyclical behavior of earnings during the analyzed period, which suggest that positive earnings growth during the last economic expansion period can be reversed. In particular, we find that a 1% short-run increase in prices is associated to a 0.5% rise of earnings, and a 1% growth in

the cyclical production variable increases earnings by 0.52%. In addition, the estimated coefficient of the production's trend component shows that an increase of 1% in this variable is associated with a rise of 0.4% in earnings.

We also find a positive relationship between prices and production variables and earnings at the sector level. This result supports the fact that earnings not only had a pro-cyclical behavior at the aggregate level, but also at the sector level. In this sense, we highlight the relationship of prices and production with earnings in four relevant sectors. In the mining-hydrocarbons sector (the boom sector during the expansion period), the increase of the cyclical component in prices explains a good part of the rise in earnings, while for the manufacturing sector the trend component of production becomes more important for explaining earnings variation.

Finally, in the agriculture, forestry and fishing sectors, the cyclical components of prices and production becomes relevant for the rise of earnings during some years on the expansion period, while the corresponding trend component has a positive effect in all the period analyzed. Finally, in the construction sector we highlight a positive relationship between the increase of earnings and the trend component of production during 2007-2011, while in the last period the cycle of production becomes the most important variable.

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Table A.1: Evolution of Earnings, and Prices and Production Components over Earnings, 1999-2012

(In percentage)

	2000	2001	2002	2003	2005	2006	2007	2008	2009	2011	2012
Agriculture, forestry, and fishing											
$\Delta \ln \tilde{w}_{hn,t}$	-0,1%	52,2%	-19,7%	29,9%	-25,4%	6,5%	-14,6%	35,1%	3,9%	42,8%	-27,3%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
$\Delta \ln p_{Cn,t}$	836,1%	0,8%	-3,2%	6,6%	5,2%	-22,0%	1,0%	12,4%	0,8%	-0,6%	1,6%
$\Delta \ln y_{Cn,t}$	-600,0%	0,7%	7,9%	7,0%	0,3%	11,2%	9,9%	0,3%	26,6%	-3,2%	-4,0%
$\Delta \ln y_{TDn,t}$	-936,8%	2,4%	-7,3%	7,9%	-8,8%	19,3%	-7,0%	2,5%	19,9%	3,6%	-3,2%
$\Delta L_{n,t}$	-292,9%	0,7%	2,4%	-14,6%	10,7%	-33,9%	0,1%	-4,2%	-49,8%	-3,2%	7,9%
Others	3,5%	95,4%	100,3%	93,1%	92,5%	125,5%	96,0%	89,0%	102,5%	103,4%	97,7%
Mining-hydrocarbons											
$\Delta \ln \tilde{w}_{hn,t}$	49,2%	-53,5%	-5,9%	47,0%	16,2%	4,4%	4,5%	-18,5%	28,3%	3,1%	15,9%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
$\Delta \ln p_{Cn,t}$	17,8%	-0,1%	-34,9%	29,2%	61,8%	193,2%	309,4%	19,2%	-6,1%	31,5%	4,5%
$\Delta \ln y_{Cn,t}$	4,9%	4,8%	15,3%	2,2%	21,6%	-57,9%	-12,8%	-29,1%	-18,3%	-3,9%	4,5%
$\Delta \ln y_{TDn,t}$	2,5%	-2,8%	-35,4%	10,0%	34,8%	84,1%	77,3%	-16,4%	8,4%	127,9%	12,1%
$\Delta L_{n,t}$	-0,1%	-6,8%	23,1%	-10,2%	-50,5%	-60,9%	-76,5%	53,7%	2,6%	-152,0%	-15,5%
Others	74,8%	104,8%	131,9%	68,8%	32,2%	-58,7%	-197,4%	72,6%	113,5%	96,5%	94,4%
Manufacturing											
$\Delta \ln \tilde{w}_{hn,t}$	2,7%	8,4%	-4,4%	3,9%	8,2%	-4,0%	-4,6%	16,1%	6,8%	12,1%	2,6%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
$\Delta \ln p_{Cn,t}$	-27,2%	0,4%	-22,3%	29,8%	3,6%	21,4%	-2,8%	8,4%	-2,1%	-1,3%	0,0%
$\Delta \ln y_{Cn,t}$	10,0%	1,0%	37,0%	32,8%	-6,2%	-27,1%	-6,9%	-4,5%	5,3%	-7,9%	27,0%
$\Delta \ln y_{TDn,t}$	46,9%	15,1%	-31,1%	64,0%	34,5%	-49,5%	-40,7%	10,7%	23,3%	24,0%	57,6%
$\Delta L_{n,t}$	-48,9%	-20,5%	-18,6%	-41,2%	-15,2%	67,9%	39,6%	-4,6%	-18,7%	-8,5%	-48,4%

Others	119,2%	104,0%	135,0%	14,5%	83,3%	87,3%	110,8%	90,1%	92,2%	93,6%	63,9%
Construction											
$\Delta \ln \bar{w}_{hn,t}$	-27,4%	7,1%	-9,5%	3,9%	14,1%	-3,2%	5,1%	20,5%	11,9%	7,7%	-0,9%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
$\Delta \ln p_{Cn,t}$	-6,6%	-2,4%	-14,4%	6,6%	-9,6%	78,7%	83,8%	-12,7%	-2,6%	-2,1%	0,9%
$\Delta \ln y_{Cn,t}$	9,8%	-41,9%	-105,3%	-231,4%	2,8%	49,1%	142,5%	-3,8%	-4,2%	-25,7%	55,3%
$\Delta \ln y_{TDn,t}$	2,5%	-17,2%	12,0%	-24,9%	10,1%	-90,6%	80,1%	21,6%	36,6%	102,2%	-399,0%
$\Delta L_{n,t}$	-4,8%	38,4%	79,3%	288,9%	-29,6%	133,4%	-134,3%	-22,7%	-45,1%	-104,3%	446,0%
Others	99,1%	123,1%	128,3%	60,7%	126,3%	-70,5%	-72,1%	117,6%	115,3%	130,1%	-3,2%
Commerce, hotels and restaurants											
$\Delta \ln \bar{w}_{hn,t}$	-24,2%	17,4%	-1,3%	-0,1%	5,7%	-1,5%	-11,8%	18,4%	21,5%	6,6%	-2,9%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
$\Delta \ln p_{Cn,t}$	4,2%	1,6%	-46,7%	-229,3%	1,8%	71,5%	-1,0%	13,7%	-0,7%	2,7%	-1,3%
$\Delta \ln y_{Cn,t}$	-3,1%	-2,8%	-2,7%	-53,6%	-2,3%	22,8%	-5,7%	0,8%	-0,6%	-3,0%	1,8%
$\Delta \ln y_{TDn,t}$	-3,9%	5,2%	-72,0%	-1059,9%	31,6%	-91,8%	-12,7%	8,4%	7,2%	45,8%	-51,4%
$\Delta L_{n,t}$	15,9%	-16,4%	130,3%	1936,3%	-51,6%	148,1%	23,2%	-13,7%	-12,9%	-79,4%	70,8%
Others	86,8%	112,5%	91,1%	-493,5%	120,5%	-50,5%	96,2%	90,8%	107,0%	133,9%	80,1%
Transport and communication											
$\Delta \ln \bar{w}_{hn,t}$	-14,8%	1,2%	-0,4%	-1,8%	6,5%	11,8%	-20,4%	17,1%	4,8%	11,6%	-1,3%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
$\Delta \ln p_{Cn,t}$	-7,9%	10,7%	-80,0%	-6,2%	-2,7%	-25,4%	13,7%	-23,0%	-1,1%	-2,6%	-0,1%
$\Delta \ln y_{Cn,t}$	1,6%	-8,0%	-177,5%	-9,1%	1,9%	-1,7%	0,7%	-2,3%	-3,3%	12,8%	96,6%
$\Delta \ln y_{TDn,t}$	-8,8%	106,2%	-371,1%	-122,8%	36,5%	14,6%	-9,2%	11,9%	45,9%	39,9%	-167,9%
$\Delta L_{n,t}$	3,5%	-89,7%	501,6%	223,8%	-56,5%	-31,1%	23,9%	-25,1%	-95,1%	-76,0%	355,4%
Others	111,7%	80,8%	226,9%	14,3%	120,8%	143,7%	70,8%	138,5%	153,6%	125,8%	-184,1%

Banking and business services											
$\Delta \ln \tilde{w}_{hn,t}$	-0,3%	-9,6%	-17,8%	-8,7%	-0,8%	11,9%	-15,4%	16,4%	-6,0%	12,3%	4,5%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
$\Delta \ln p_{Cn,t}$	-41,4%	14,5%	0,5%	3,7%	35,8%	-15,9%	6,5%	-2,1%	-0,6%	-2,6%	2,3%
$\Delta \ln y_{Cn,t}$	650,8%	4,3%	9,1%	8,7%	98,8%	12,5%	-7,1%	0,3%	11,9%	-4,8%	36,9%
$\Delta \ln y_{TDn,t}$	-459,7%	-5,8%	0,6%	3,7%	-58,3%	9,5%	-10,7%	12,1%	-37,2%	41,1%	60,7%
$\Delta L_{n,t}$	410,7%	8,9%	2,6%	4,4%	47,9%	-3,1%	4,2%	-2,8%	14,6%	-10,5%	-18,5%
Others	-460,3%	78,2%	87,2%	79,6%	-24,1%	97,0%	107,1%	92,5%	111,3%	76,9%	18,6%
Other social services											
$\Delta \ln \tilde{w}_{hn,t}$	-9,3%	5,2%	10,3%	-6,1%	15,1%	-0,3%	-7,9%	12,5%	3,5%	0,2%	3,9%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
$\Delta \ln p_{Cn,t}$	1,4%	64,0%	10,1%	-39,5%	1,9%	1090,7%	26,5%	-19,1%	1,8%	-2,4%	-0,1%
$\Delta \ln y_{Cn,t}$	4,3%	-3,2%	1,1%	-3,2%	-1,1%	105,9%	2,0%	-3,5%	61,5%	48,7%	-36,8%
$\Delta \ln y_{TDn,t}$	-13,4%	22,9%	11,2%	-29,4%	12,7%	-492,6%	-21,6%	16,0%	64,3%	2303,4%	65,3%
$\Delta L_{n,t}$	52,6%	-101,9%	-13,6%	30,7%	-13,3%	562,9%	22,7%	-12,8%	-62,5%	-2052,6%	-61,8%
Others	55,1%	118,2%	91,2%	141,5%	99,8%	-1167,0%	70,4%	119,4%	34,9%	-197,1%	133,4%

Source: Prepared by authors based on data of the Bolivian Institute of Statistics (INE).