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Carlos Foronda
Javier Beverinotti

Inter-American Development Bank
Country Department Andean Group

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Effects of innovation on employment: An analysis at the firm level in Bolivia

Carlos Foronda
(Universidad Privada Boliviana)
Javier Beverinotti
(InterAmerican Development Bank)

Summary

This study quantifies the impact of process and product innovation on employment growth in Bolivia by using microdata from a survey on innovation conducted in Bolivia in 2016. Following the model of Harrison, Jaumandreu, Mairesse, and Peters (2008) and the adaptations for Latin America of Crespi and Tacsir (2013) and Elejalde, Giuliodori, and Stucchi (2015), we demonstrate that employment growth is explained by product innovation. On the other hand, we find no evidence of a displacement effect due to process innovation. With respect to innovation and work composition, we observe that the creation of qualified employment is slightly favored over that of unqualified employment.

Classification JEL: D2, O12, O14, O31, O33, O40
Key words: employment, product innovation, process innovation, productivity

1. Introduction

For more than a decade and ending in 2018, Bolivia experienced significant economic growth, around 5% of its GDP. A significant part of this growth can be attributed to the export of commodities[1] and the increase in the prices of those commodities through the end of 2014.

Economic growth in the country, as well as in most economies of Latin America and the Caribbean (LAC), can also be explained, in large part, by the accumulation of capital and work, rather than increases in productivity or advances in innovation (BID 2016). The level of investment in research and development (R+D) in Bolivia is low when compared to the average for the region and to other more economically developed countries: it is estimated that Bolivia invests approximately 0.16% of its GDP in R+D, as opposed to the regional average of 0.65% and the average, 2.4%, of countries belonging to the Organization for Economic Co-operation and Development (OECD) (OECD, 2020). The differing levels of participation by the private sector in this type of activity are a significant driver of this discrepancy. Whereas on average 58% of the investment in innovation come from the private sector in OECD countries, in Bolivia the percentage barely reaches 5.9% (Beverinotti, Canavire-Bacarreza, & Chacón 2020).

The outbreak of COVID-19 in the region and in the country in particular may produce significant economic and social changes in the coming years. Value chains have been affected by the development of the pandemic, and a significant decline in the prices of commodities has been observed, which may negatively influence the growth of the country. In this new scenario, the Bolivian government faces the challenge of designing and implementing policies that look to increase productivity and eventually put the country back on the path of economic growth. To achieve that, policies oriented toward innovation rather than toward the production of commodities are needed (Aguerrevere, Amaral, Bentata, & Rucci, 2020). On the other hand, it will be essential to implement active policies supporting employment to reduce, or at least avoid, the worsening of levels of poverty and inequality due to the pandemic (World Bank, 2020).

Even though there have been good experiences in Bolivia, it will not be easy for the government to lead the country toward an economic model in which knowledge and innovation play a more significant role, in particular due to the current situation of innovation, science and technology (Cirera & Maloney, 2017). One characteristic of the Bolivian economy is the low participation of the private sector in recent years. In 2016, private investment in the country was around 7.5% of GDP, while in countries of the region like Colombia and Peru, private investment was around 20% of GDP (Beverinotti, Canavire, & Chacón 2020). Furthermore, at 5.9% of GDP, investment by the private sector in innovation activities is substantially lower than the average of 38.8% by the private sector in LAC as a whole. This low level of participation has been one of the factors responsible for the loss of competitiveness and a decline in entrepreneurial and workforce productivity in the country. According to the Conference Board (2019), Bolivia has the lowest productivity of the LAC countries for which there are data.[2]

[1] During the past decade, the contribution of mining and quarrying to economic growth was close to 10% (see INE) and commodities exports like hydrocarbons and minerals increased approximately 10% annually.
[2] To obtain the output of one worker of a product in a country like United States, eight Bolivian workers are needed. Similarly, Bolivia lags behind countries like Chile (3.5 times more productive) or Uruguay (3.2 times more productive), according to The Conference Board (2019).

On the one hand, as suggested by Cirera and Maloney (2017), the way for developing countries to improve their competitiveness and productivity[3] is by investing in innovation. However, the flaws of the market and the lack of complementarities between the supplies and factors of production complicate the formulation of the innovation policies that are necessary. The weak capacity of governments to design, implement, and coordinate effective policies must be kept in mind as well.

The effects of policies oriented to increasing investment in innovation may be ambiguous in relation to levels of employment. Empirical evidence on developed economies suggests that innovation may have as a first effect destruction of employment when improving efficiency (Brynjolfsson & McAfee 2011; Evangelista & Vezzani 2012). However, in the medium term it can reduce costs and stimulate demand for the products of innovative firms, increasing these firms' demand for employment. This compensatory effect may generate a final net increase in employment, even when innovation is conceived of as a way to improve work efficiency.[4]

In LAC countries the ways of innovation tend to be quite varied, and businesses usually are micro and small firms. Therefore, it is necessary to conduct studies with data from these countries, using the findings from developed countries as a guiding framework.

While the limited evidence presented thus far is positive, as the level of innovation and productivity have grown during the last few years, more data, and studies about the relationship between innovation and productivity in countries of LAC are needed (Crespi & Zúñiga, 2012; Angelelli, Luna, & Vargas, 2016; Foronda, Beverinotti, & Suaznábar, 2018). At the same time, there is not enough empirical evidence about innovation and employment in the region (Crespi & Tacsir, 2013; Benavente & Lauterbach, 2008; Elejalde, Giuliodori, & Stucchi, 2015). In Bolivia, this type of study may deepen understanding of the effects of innovation and inform monitoring of development policies in the country in the medium term.

Informed by the evidence from developed countries (Harrison, Jaumandreu, Mairesse, & Peters, 2008) and the advances in the studies conducted in the region (Crespi & Tacsir, 2013; Benavente & Lauterbach, 2008; Elejalde et al., 2015), this working paper explores the effects of product and process innovation on employment growth in manufacturing and services firms in the country, using data from the Science, Technology, and Innovation Survey (STI) of Bolivia. Based on these data the differentiating effects of either creation or destruction of qualified and unqualified[5] employment may be also evaluated.

Given the circumstances of the COVID-19 pandemic, the economic collapse, and the demand for basic products that countries like Bolivia export, it is essential to study new

[3] In developed countries, low productivity is due, in part, to a low level of investment in innovation activities, which, according to Griliches and Mairesse (1995), is especially important for explaining the growth of total factor productivity (TFP). These authors show that investment in innovation is responsible for up to 75% of productivity growth. Other authors, like Hall and Jones (1999), show that up to 50% of the variation in levels of GDP per capita of the countries is explained by variation in TFP.

[4] In developed countries, there is no certainty as to how or which mechanisms affect employment prior to this type of investment (Harrison et al., 2008; Vivarelli, 1995, 2014; Piva & Vivarelli 2005), even though investment in innovation usually has net positive effects on employment (Harrison, Jaumandreu, & Mairesse, 2014).

[5] Qualified workers are those who have completed technical or graduate studies. Unqualified workers are those with primary or secondary school education or no formal education at all.

ways to boost growth. A viable option would be for Bolivia to foster economic growth and development through a modern national system of innovation. This could be supported with a deep understanding of the relationship between innovation and employment growth. This knowledge may provide new tools to use resources more efficiently, to guide new policies of innovation according to the characteristics of the environment, to promote new specific strategies (according to the region, type of industry, size of the firm, etc.) and to adapt policies of developing human resources.

1.1 Current situation of public policies in Bolivia related to Science, Technology and Innovation (STI)

Before we turn to the analysis of the relationship between work and innovation in Bolivia, it is necessary to provide an overview of the relevant policies that have been implemented. Areas of STI and productive development have been prioritized within strategic plans of the government. Back in 2007, the National Plan of Development included the creation of a Bolivian System of Innovation (BSI) and policies of STI seemed to be key to supporting the productive sector with the purpose of consolidating an inclusive technological and scientific culture crucial for a society of knowledge. This last item is reinforced by the Bicentennial Patriotic Agenda 2025 (Agenda Patriótica Bicentenario, 2014), in which the fourth and sixth pillars refer to scientific and technological sovereignty, as well as diversified productive sovereignty with integral development (Ministerio de Autonomías, 2013).

There have not been significant advances since the publication of the National Plan of Development in 2007, despite the strategic relevance of these topics. To this point, advances have been only noted at the sectoral level, with no possibility of making multisectoral and transversal interventions to support STI. As to the financing of research, development, and innovation activities (R+D+i), the only advance has been the use of funds generated by the Direct Tax on Hydrocarbons,[6] which have been substantially reduced since 2014 (Foronda et al. 2018).

While there is a tradition of interventions to support STI in agriculture in Bolivia, similar efforts to support transversal scientific development have been lacking (Ministry of Productive Development and Plural Economy, 2016). Initiatives have been launched separately by the Ministry of Education and by the Vice Ministry of Science and Technology (VMS and T) within the framework of the National Science, Technology and Innovation Plan (2013), which has the goal of changing the productive matrix. However, thus far funding for the research and technological innovation promoted in the plan (Ministerio de Educación, 2013) have not been implemented. With respect to strengthening the development capacity of STI, the Vice Ministry of Education is financing scholarships for postgraduate studies (master's and doctorate postgraduate degrees) in strategic areas. The Ministry of Productive Development and Plural Economy and the PROBOLIVIA agency have provided funds to support innovation and the improvement of managerial skills in small firms and producers, as well as the opening of six Centers of Productive Innovation, with their main function being to provide technological extension and lab services to firms (Ministerio de Desarrollo Productivo y Economía Plural, 2016).

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[6] Approximately 8.62% of the funds collected through the Direct Tax on Hydrocarbons (IDH) are earmarked for public universities. This money can be spent on infrastructure and academic equipment; evaluation and accreditation to meet current regulations; programs for quality improvement and academic performance; scientific research, technology, and innovation within the framework of development and production plans at the national, departmental, and local levels; and programs of social welfare mainly targeted to vulnerable populations with high rates of poverty.

1.2. Strategic framework for innovation policies

Bolivian firms have not made investment in R+D a priority, in part due to high costs. In a possible first stage of development of this type of strategy, innovation imported from other economies could increase production and productivity. There is evidence in the literature that for developing countries, the acquisition of technology/knowledge from abroad, commercial exchanges, and collaboration with industrialized countries may contribute toward increasing innovation for the firms, complementing technological efforts made in certain type of industries and firms (Harrison et al., 2008; Crespi & Tacsir, 2013; Elejalde et al., 2015). Foronda et al. (2018) have presented evidence of such in the case of Bolivia.

Existing literature on this topic and LAC countries suggests that firms that are large and/or are under foreign proprietorship tend to be associated with higher implementation of STI (in particular in manufacturing sector). There is strong evidence in these countries of the relationship between an increase in the uptake of innovation and an increase in the number of qualified workers (Monge-González et al., 2011; Crespi & Tacsir, 2013; Elejalde et al., 2015).

The core of the analysis of this study takes up the effect of the relationship between investment in innovation and employment growth in firms in Bolivia. Here it is necessary to make a distinction between innovation in processes and innovation in products. The latter type may be reflected in significant changes in already existing products or totally new products offered by firms, domestically and/or internationally. At the same time, using the available data it will be crucial to separate out qualified and unqualified employment to fully assess the effect of innovation on employment.

This information should aid the design of policies by specifically identifying how different strategies of innovation bring about the creation or destruction of employment. For instance, firms that decide to invest in innovation usually adopt *development of innovation programs* from programs of investment and development, educating and training human resources or else taking up innovation from abroad through the purchase of equipment, machinery, technology, or codified knowledge. This allows firms to optimize resources and reduce the number of unnecessary job positions; at the same time more employment is generated by the greater demand (Monge-González et al., 2011). To implement policies at the country level, it is essential to be familiar with the results that investment in innovation (through these or other programs) generates in terms of employment and firms' productivity.

If the capacity to innovate of firms strongly depends on the skills of their workforce, as Crespi and Zuñiga (2012) observe, then firms will have to invest in developing such skills and improving employability and workforce productivity, and by extension the performance and competitiveness of firms will improve (Monge-González et al., 2011; Crespi & Tacsir, 2013; Elejalde et al., 2015).

The rest of the paper is organized as follows: in section 2 the analytical framework is delineated. In section 3 data and some descriptive statistics of innovation and employment in Bolivia are presented. In section 4 the main results of econometric estimations are presented, and in section 5 different robustness tests that validate the estimates obtained are described. In section 6 the implications of the effects of different types of innovation on employment growth are presented. Finally, in section 7, the study's main conclusions and recommendations are discussed.

2. Analytical framework: innovation and employment creation

In Harrison et al. (2008) a new way to study the effect of product and process innovation on the creation and displacement of employment is introduced. On the one hand, the implementation of new processes usually has the goal of lowering costs and tends to reduce jobs (displacement effect). On the other, the implementation of new products or services, which may replace or add to existing products or services, generates different effects on the creation of employment. There are also effects from organizational innovation as a relevant component of the acquisition of new technologies on productivity and employment.

Table 2.1 Potential effects of innovation on employment

		Displacement	Compensation		
Innovation Activities →	Tendency to productivity Process Innovation	Productivity Effect (-): less employment for a volume of output given	Price Effect (-): reduction of costs, transfer to prices, expansion of demand	←	Depends on behaviour of the firm
	Product Innovation	Differences in productivity for a new product (+/-)	Effect of enlargement of the demand (+)	←	Depends on competition

Source: Extracted from Harrison, Jaumandreu, Mairesse, and Peters (2014).

Table 2.1 from Harrison, Jaumandreu, Mairesse, and Peters (2014) summarizes the most relevant effects of process and product innovation activities on the creation and displacement of employment. On the one hand, process innovation is directed toward improving production processes in order to have an impact on productivity and unit costs. On the other, product innovation seeks to expand existing demand or create new demands for the firm. As observed in Table 2.1, both types of innovation may be interpreted as the result of innovation activities carried out by a firm. Moreover, the level of productivity may increase annually due to the implementation of training (tendency toward productivity).

An increase in productivity comes from process innovation and tendency to productivity and implies a reduction of unit costs. Low prices result in an increase in demand, output, and employment. However, the effects of compensation and displacement also depend on firms’ behavior and competition.

Product innovation may also affect productivity, even when it is not related to process innovation. The major effects of the use of new or improved products on employment are caused by an increase in demand. Again, the relevance of an increase in demand depends on the nature of the competition and how rival firms react to those new products. At the same time, it should be noted that output of new products may reduce potential output of already existing products from innovative firms.[7]

Following the analysis of Harrison et al. (2014) for developed countries and Crespi and Tacsir (2013) for LAC, this study considers three types of firms: non innovative, product innovative and process innovative. Net rates of change of employment in the industry depend on interaction and decision-making of these three types of firms.

[7] This will depend on the degree of substitution of old products by new or significantly improved products. According to Cirera and Maloney (2017), it should also be kept in mind that investment in innovation may reduce the level of productivity at first, due to the requirement of supplies, factors, and complementarities, which diverts resources; however, evidence suggests that in the medium and long term, productivity ends up at a higher level than it was before.

2.1. Specifications of the model

Following Harrison et al. (2008), in the basic model firms manufacture two types of products: already existing and new. In this way, changes in employment may be decomposed on the one hand due to an increase in the efficiency of production of already existing products (usually related to process innovation) and on the other, due to the introduction of new products (product innovation). Thus, it is possible to identify creation effect and displacement effect of innovation on employment.

From the adaptation for LAC countries in Crespi and Tacsir (2013) and Elejalde et al. (2015), during period *t* firms introduce two types of products, already existing or marginally modified (Y_{1t}) and new or significantly modified (Y_{2t}). Considering a separable production function for existing and new products with constant returns of scale for capital and labor, technology and production may be described as follows:

(1) $$\mathrm{Y}_{it} = \theta_{it} F(L_{it}, K_{it}, M_{it}) e^{\eta+\omega_{it}}$$

where *F(.)* is a homogeneous function of degree 1 in labor (L_{it}), capital (K_{it}), and intermediate goods (M_{it}); θ_{it} is a parameter of Hicks technological change, which may depend on process innovation; and $e^{\eta+\omega_{it}}$ is the unobserved productivity on the part of firms that may be decomposed in attributes of the firm that do not vary over time (η) and in productivity shocks (ω_{it}).

Under perfect competition conditions for market supplies, the cost function of firms for period *t* is

(2) $$\mathrm{C}_t(w_t, \mathrm{Y}_{it,} \mathrm{Y}_{2t}) = c(w_t)\left(\frac{\mathrm{Y}_{1t}}{\theta_{1t} e^{\eta+\omega_{1t}}} + \frac{\mathrm{Y}_{2t}}{\theta_{2t} e^{\eta+\omega_{2t}}}\right)$$

where w_t represents the cost of supplies, and the conditional demand of employment function is

(3) $$L_{it} = c_{w_L}(w_t) \frac{\mathrm{Y}_{it}}{\theta_{it} e^{\eta+\omega_{it}}}$$

where w_L is employment costs y $c_{wL} = \partial c / \partial wL$

Using the demand of employment function, employment growth at a firm level can be obtained as

$$\frac{\Delta L}{L} \approx \log\left(\frac{L_{12}}{L_{11}}\right) + \left(\frac{L_{22}}{L_{11}}\right)$$
$$= -(log\theta_{12} - log\theta_{11}) + (logY_{12} - logY_{11}) + \frac{\theta_{11} Y_{22}}{\theta_{22} Y_{11}} + (\omega_{12} - \omega_{11})$$

In this way, employment growth is decomposed into (1) an increase in efficiency in the manufacture of already existing products (which may be related to process innovation), (2) the output of already existing products and (3) the introduction of new products. On the one hand, the increase in efficiency of the production of already existing products is expected to be higher for firms that introduce process innovation only. On the other, the effect of product innovation on employment growth depends on the difference in the efficiency between the processes of manufacture of existing products and new ones. If new products are manufactured with greater efficiency than existing products, then the ratio is less than one and employment does not grow at the same rate of the new products. This suggests the following equation to estimate effects of innovation on employment:[8]

(4) $$l = \alpha_0 + \alpha_1 d + y_1 + \beta y_2 + v$$

where l is total employment growth, y_1 is real growth of output of existing products, y_2 is real growth of output of new products ($logY_{12} - logY_{11}$ *and* $logY_{22}/logY_{11}$, respectively). The parameter α_0 represents average growth of efficiency in the manufacture of existing products. The binary variable *d* captures the additional effect of process innovation related to the production of existing products from parameter α_1. The error v captures productivity shocks. The parameter β captures the relative efficiency of the production of existing and new products.

Finally, it is expected that process innovation existing products displaces (reduce) employment due to an increase in efficiency. At the same time, product innovation tends to create employment (unless new products substitute for existing products and efficiency in the production of new products is the same or higher than that of the production of existing products). So, β in equation (4) captures relative efficiency in the production of existing and new products (θ_{11}/θ_{22}). When $\beta < 1$ ($\beta>1$), new products are manufactured with higher (less) efficiency than existing products.[9]

Given the foregoing, it follows that the effects of innovation on employment depend on the type of innovation implemented. Considering that innovation may be considerably different in different sectors, it is natural to assume that the effect of innovation on employment may also be different in different sectors (due to the fact that different types of firms react to labor regulations, rigidities in the market, and informality in different ways). Heterogeneity may have major implications for policies. In this sense, this paper explores the heterogeneity of the impact of innovation on employment by size and economic sector, among others. However, the size of the sample in the survey makes this line of analysis difficult.

2.2. Identification and measurement errors

Identification in the estimation of the equation (4) may be affected by two different problems: potential endogeneity of the variables of innovation and measurement errors generated by using nominal variables instead of real variables between regressors.

With the purpose of understanding the problem of endogeneity, following Harrison et al. (2014), productivity may be decomposed into two unobserved components: attributes of the firm that do not vary over time (management capacity or organizational capital [η]) and productivity shock (which may allow the firm to reduce costs [ω_t]). Thus, if innovation activities are related to productivity, the results of innovation will be related as well, resulting in endogenous results and an identification problem. In this case, coefficients estimated by ordinary least squares (OLS) will not be consistent.

Equation (4) is specified in terms of growth; therefore, the part that is not related to time is removed from the error term. In this sense, only productivity shocks remain as a

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[8] The development of the equation follows Harrison et al. (2014), where more details are shown.

[9] However, real output growth of existing products y_1 is the result of three different effects: 1) autonomous growth in the demand of existing products, 2) a compensation effect induced by any change in prices due to process innovation, and 3) a demand substitution effect as a result of the introduction of new products. While these components cannot be separated from additional data, in practice y_1 will simply be the subtraction of 1, and an alternative specification for (4) will be to use the reverse of growth of workforce productivity as a dependent variable.

source of correlation between innovation results and productivity.

As presented by Harrison et al. (2014), correlation between innovation results and productivity shocks depends on when the investment decision is taken (business cycle). If investment decisions are taken before productivity shocks (due to the time the period of construction and installation take), innovation variables of equation (4) will not be correlated to the error term, and the equation may be estimated by OLS. If investment decisions are taken at the same time as productivity shocks are observed, the results of innovation will be endogenous.

The problem of identification of a real relationship depends on availability of the instrument correlated to innovation variables and not correlated to the error. Additionally, variables of the innovation survey have information that may be used as an instrument to identify innovation in a product before innovation in a process, which is a more idiosyncratic result.

Additionally, most of the firms of the sample implement product innovation and process innovation at the same time (these firms are considered product innovators, and some may be considered co-innovators) and the number of firms that only implement process innovation is small (as in Crespi and Tacsir [2013], any bias toward process innovation in employment growth is expected to be low). On the other hand, innovation expenditures may be carried out before they result in applicable innovations. It is possible to assume that firms cannot predict future problems, demand shocks, and organization shocks, and so forth while deciding on their innovation costs.

Considering the aforementioned arguments and considering that empirical implementation is controlled by unobserved invariables in time and specific temporary shocks in the industry, there are enough arguments to determine that process innovation is exogenous. However, robustness tests were carried out to verify this assumption. To sum up, the study's empirical implementation concentrates on product innovation, considering process innovation as exogenous.

Another source of endogeneity may come from errors in measurement. Thus, to avoid this type of error, real growth of output of existing (y_1) and new products (y_2) should be obtained; however, only growth of output in nominal terms (g_1 y g_2) is available. Considering $g_1 = y_1 + \pi_1$ for old products and $g_2 = y_2 + \pi_2$ for new products, π being change in prices, the following is obtained:

(5) $$l - g_1 = \alpha_0 + \alpha_1 d + \beta g_2 + (-\pi_1 - \beta\pi_2 + v)$$

As observed in equation (5), the growth in prices of old and new products is found in the error term, so that correlation between prices and g_2 generates a bias in the estimation of β.

To solve this problem, the estimate of Harrison et al. (2014) is used. First, the GDP price deflator (π_1) is used as a proxy for the rise of prices of existing products (π). In this way, it is estimated that

(6) $$l - (g_1 - \pi) = \alpha_0 + \alpha_1 d + \beta g_2 + (-(\pi_1 - \pi) - \beta\pi_2 + v)$$

Assuming that the prices level is not considerably deviated from prices level from the GDP deflator, it is anticipated that $\pi \sim \pi_1$. In this sense, consistent estimates may be obtained.

These endogeneity problems, which may be a source of bias in the estimation of OLS, may be approached using the method of instrumental variables. In this way, we look for variables that are correlated to real growth, and not to nominal growth, of production of new products.

2.3. Innovation and employment qualification

If innovation has a bias in employment qualification, as several empirical and theoretical studies suggest (Bresnahan & Levin, 2012; Caroli & Van Reenen, 2001), its impact may differ, depending on whether employment is qualified or unqualified.

To analyze the effect of innovation on employment composition, equation (6) is divided into the rates of qualified and unqualified employment growth:

$$l^{c} - (g_1 - \pi) = \alpha_0^{c} + \alpha_1^{c} d + \beta^{c} g_2 + \varepsilon \tag{7}$$

$$l^{nc} - (g_1 - \pi) = \alpha_0^{nc} + \alpha_1^{nc} d + \beta^{nc} g_2 + \eta \tag{8}$$

The dependent variable is employment growth (minus growth of real output of existing products) for both types of employment (qualified and unqualified). Using equations (7) and (8), the effects of product and process innovation on the growth of qualified and unqualified employment can each be evaluated separately.

As mentioned above, in order to approach the problem of identification related to the correlation between d and g_2 and error terms, the instrumental variable method is used.

3. Data characteristics

3.1 Data set

The first innovation survey of private firms in Bolivia was conducted in 2016, based on the Oslo Manual of OECD and Eurostat (OECD and Eurostat 2005). The sample consisted of private firms located in three departments (La Paz, Cochabamba, and Santa Cruz) and represented 70% of the formal small, medium, and large-size firms of the country.[10] The survey covered business activities over 2013, 2014, and 2015. The framework sample of the survey came from FUNDEMPRESA's Board of Directors (an agency subordinate to the Ministry of Planning), in charge of elaborating and updating the formal registration of firms in the country.

The survey provides microdata from Bolivian knowledge-intensive business service firms (KIBS, its acronym in English), which can be compared to other such firms in LAC countries (Chile, Colombia, Costa Rica, Uruguay, Panama, and Paraguay, among others). However, when making comparisons the differences between business environments, economies, and political contexts across these countries should be considered.

3.2. Data Description

Innovation surveys capture information concerning the characteristics of firms, their innovation activities, and employment, from the number of employees to the composition of the workforce by level of education. They also capture information

[10] The size of the firm is defined by the number of employees. Thus, small-size firms have from 5 to 20 employees; medium-size firms have from 21 to 50 employees, and large-size firms have more than 51 employees.

about output composition, which enables the calculation of the percentage of output corresponding to new products and the rate of nominal growth of output of new products (g_2).

In the survey, firms were asked about the proportion of output(s) at the end of the period as the result of product innovation implemented during the period. The survey also collected information about the rate of nominal growth of total output (g). Thus, given that the output of new products at the beginning of the period is zero by definition, it is possible to obtain the rate of nominal growth of output of new products: $g_2 = s(1+g)$.[11]

To deflate nominal variables, information about prices of the implicit GDP deflator at two digits is used. Aggregate information about prices is available, but not information at the firm level. Consequently, prices may vary among firms and even within the same firm when referring to multiproduct firms. The use of a two-price index introduces the problem of measurement error in the estimation. The instrumental variable method is used to correct bias.

According to Harrison et al. (2008), firms that have implemented both product and process innovation are classified as product innovative, because it is assumed they share more similarities with product innovative firms than with firms that are only process innovative. Firms were classified in an exclusive manner: product innovators,[12] process innovators only, and noninnovators.

In table 3.2.1, descriptive statistics data are presented for innovative firms: employment growth, output growth and workforce productivity (defined as real output per worker). Of the Bolivian firms surveyed, 49% implemented at least one innovation between 2013 and 2015. The innovations have related much more to products (40%) than to processes (9%). These results are like those Elejalde et al. (2015) found for Argentina. Even though the percentage of innovative firms may seem to be high (on a par with some European countries; see Harrison et al., 2014), innovation by firms in Bolivia is concentrated on technology acquisition, while in European countries the focus is on R+D.[13]

A key characteristic of firms in Bolivia is the average number of employees (53 employees), which is significantly lower than in the rest of LAC countries (233 employees in Argentina, 214 in Chile, 182 in Costa Rica, and 91 in Uruguay).

Employment growth was similar for innovative and noninnovative firms. In annual terms, employment increased 14% for product innovative firms, 9% for process innovative firms, and 14% for noninnovative firms. This may reflect the economic cycle in Bolivia at the time of the survey, as was the case with the results for different LAC countries analyzed in Crespi and Tacsir (2013). Those authors observed on the one hand a 6% drop in employment for noninnovative firms and 2.5% drop for product innovative firms in Argentina,[14] and on the other an increase of 3.5% for noninnovative and of 7.4% for process innovative firms in Uruguay.

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[11] For the details of the calculation of $g1$ and $g2$, see Elejalde et al. (2015).

[12] The fact that they are product innovators implies that 1) they are product innovators only or 2) they are product and process innovators.

[13] This is one of the reasons why results for developed countries can be used as a benchmark, given the differences in innovation among countries.

[14] During the data collection by Crespi and Tacsir (2013), Argentina was experiencing one of the worst economic recessions in its history.

Regarding type of employee, 55% in the firms surveyed were qualified. In product innovative firms the percentage was somewhat higher (58%); 53% of employees in both product innovative noninnovative firms were qualified.

Innovative firms have seen more growth in the number of qualified employees than noninnovative firms. The increase for product innovative firms was 18% and for process innovative firms 20%, while for noninnovative firms the increase was 13%. At the same time, the growth of unqualified employees in innovative firms was also higher: there was an increase of 23% for product innovative firms and of 13% for process innovative firms, but in noninnovative firms it was 12%.

Despite differences among countries, it is worth noting that (except in Chile) innovative firms in LAC countries seem to perform better in terms of employment creation. In Bolivia and Argentina (Elejalde et al., 2015), this is particularly true regarding the growth of qualified employment.

As was the case with employment growth, output growth was higher for product innovative firms than for noninnovative firms. The increase in annual output for product innovative firms was 33%, for process innovative firms it was 19%, and for noninnovative it was 22%.[15]

For product innovative firms, output growth is decomposed into existing products (g_1) and new products (g_2), as explained above. As in Argentina (Elejalde et al., 2015), it is noteworthy how quickly product innovative firms substitute for existing products. The 25% decline in output of existing products is more than compensated for by a significant increase in output growth of new products of 62%.

The increase in labor productivity for product innovative firms was 15%, for process innovative firms 6%, and for noninnovative 4%. These results suggest that innovative firms are better positioned to take advantage of positive shocks to the economy (or alternatively to overcome a negative shock, as observed in the case of Argentina by Elejalde et al., 2015).

Table 3.2.1
Descriptive statistics

	Mean	s.d.	N
Distribution of firms (percentage)			
Noninnovators (without product or process innovation)	0.51	0.50	422
Process only (noninnovative in products)	0.09	0.29	422
Product innovators	0.40	0.49	422
Average number of employees in 2013	53.5	220.3	422
Average number of employees in 2015	56.5	241.3	422
Foreign proprietorship (1 if 10% or more)	0.05	0.22	422
Located in La Paz	0.29	0.45	422
Located in Cochabamba	0.37	0.48	422
Located in Santa Cruz	0.34	0.47	422
Proportion of qualified employment, 2015			
All firms	0.55	0.33	422
Non innovators (without product or process innovation)	0.53	0.34	213

[15] When the innovation survey was conducted in Bolivia, a high rate of lack of answers was expected with respect to values of output. For this reason, a strategy to capture data in two stages was adopted. In the first stage, questions directly related to values were asked. If no answer was provided, in the second stage several options in terms of answers were presented (to allay the fear of entrepreneurs regarding the disclosure of sensitive information). With this strategy, close to 80% of the firms provided answers. Were this strategy not employed, approximately only 50% of the firms would have provided answers (for more details, see Foronda et al., 2018).

Process innovators only (without product innovation)	0.53	0.33	39
Product innovators	0.58	0.33	170
Employment growth (percentage)			
All firms	0.14	0.43	422
Noninnovators (without process or product innovation)	0.14	0.44	213
Process innovators only (without product innovation)	0.09	0.39	39
Product innovators	0.14	0.44	170
Qualified employment growth (percentage)			
All firms	0.15	0.58	422
Noninnovators (without product or process innovation)	0.13	0.49	213
Process innovators only (without product innovation)	0.20	1.15	39
Product innovators	0.18	0.48	170
Unqualified employment growth (percentage)			
All firms	0.17	0.73	422
Noninnovators (without product or process innovation)	0.12	0.68	213
Process innovators only (without product innovation)	0.13	0.47	39
Product innovators	0.23	0.84	170
Output growth (percentage) (nominal)[a]			
All firms	0.26	0.62	422
Noninnovators (without product or process Innovation)	0.22	0.58	213
Process innovators only (without product innovation)	0.19	0.52	39
Product innovators	0.33	0.68	170
Productivity growth (percentage)[b]			
All firms	0.08	0.59	422
Noninnovators (without product or process innovation)	0.04	0.54	213
Process innovators only (without product innovation)	0.06	0.58	39
Product innovators	0.15	0.65	170
Price growth (percentage)[c]			
All firms	0.04	0.05	422
Noninnovators (without product or process innovation)	0.04	0.05	213
Process innovators only (without product innovation)	0.04	0.06	39
Product innovators	0.05	0.03	170

Source: Science, Technology and Innovation Survey conducted in Bolivia in 2016.
Note: Product innovators are firms that implemented innovations between 2013 and 2015. Process innovators only are firms that implemented innovation in processes or organizational changes but not in products between 2013 and 2015. Noninnovators are firms not classified as product or process innovators. Qualified workers are employees with graduate or tertiary degrees (one- to three-year degrees related to technical professions). Unqualified workers are employees with primary or secondary education. Rates of growth are annual. The sample is composed of firms that provided information for all relevant variables for the empirical analysis.
[a] Output growth for each type of firm is the weighted average of growth rates for all the firms surveyed.
[b] Workforce productivity is measured as real output per worker.
[c] Prices calculated from the GDP implicit deflator at two digits and assigned to firms according to their activity.
s.d. = standard deviation.

4. Estimation results

The great advantage of the work of Harrison et al. (2014) is the use of economic theory to model mechanisms of interaction between innovation and employment. The authors derive equation (6), which enables the estimation of the relationship between product and process innovation and employment decisions, under the assumption of perfect competition in market supplies and technology of firms. The estimation of equation (6) yields parameters with useful economic interpretation, as opposed to the estimation of the relationship between innovation and employment in a reduced way (equation 4). In this last case, parameters are estimated that are difficult to interpret and thus distinguishing interaction mechanisms is especially challenging.

As in Harrison et al. (2014), Elejalde et al. (2015), and Crespi, Tacsir, and Vargas (2015), at first an explanatory estimation of the equation (4) is carried out. This estimation is done for two reasons: 1) to show the difficulty in interpreting the relationship between innovation and employment without imposing an alternative structure and 2) to justify the variable of product innovation (as the combination of product innovation only and product and process innovation). The estimation is presented in table A.1.

The results obtained in this estimation may be considered as simple correlations that can describe data; however, they do not allow the interpretation of the effects of innovation on employment (the interpretation of the coefficients of the model is difficult). Per Table A.1, there are no significant statistical differences between product innovators only, process innovators only, and product and process innovators. It would be an especially complex task to estimate the effects of employment separately for process innovators only, product innovators only and process and product innovators. Thus, it was decided to group all firms that are product innovators (product innovators only and product and process innovators).

4.1 Innovation and employment

In Harrison et al. (2014), a model for different countries of Europe is estimated. Crespi et al. (2015) estimate the model for LAC countries but do not include Bolivia. The evidence presented in these works may be used as reference points, taking into account the particular characteristics of each context, as a way to compare effects of innovation on employment in Bolivia.

In Table 4.1.1, the estimation of the effect of innovation on employment from the model in Harrison et al. (2014) is observed, as presented in equation (6). The estimation is controlled by dichotomic variables from the industry at two digits, a dichotomic variable which indicates whether the firm or headquarters is located in the Department of Santa Cruz,[16] and a dichotomic variable that denotes foreign participation in the proprietorship of the firm.

In the first part of the table, the estimation for OLS is presented. Product innovation has a positive and significant effect on employment. The estimated coefficient for g_2 is less than 1, evidence that new products are manufactured more efficiently than existing products. In contrast, the results show that process innovation, d, has no significant effect on employment.

In the next part of the table, the estimation by instrumental variables is presented (IV), due to the fact that there may be two endogeneity problems that biased the estimation for OLS, namely 1) the problem of the omitted variable: productivity shocks may be included in error terms (negative), and 2) the problem of measurement error: prices at the firm level are unobserved. Both problems tend to generate a negative bias in the estimation of OLS in the coefficient of g_2.

For the estimation by IV an indicator of the knowledge of the firm (though it may not be a user) of public support for innovation activities is used as an instrument. The variable is more related to coverage and broadcast of the public support system rather than innovation activities carried out by the firms. The same instrument was used in Argentina by Crespi and Tacsir (2013) and Elejalde et al. (2015).

The estimation strategy is based on the fact that knowledge of public programs is exogenous once it is controlled by the type of industry, location, and invariant productivity over time. This argument is supposed to be valid, as in Elejalde et al. (2015), given that only large productive firms will be willing to invest in expensive information. Taking this into consideration, it is controlled by productivity. Likewise, it

[16] The Department of Santa Cruz is chosen because most of the country's firms are located there.

seems less likely that firms will decide to invest in information due to productivity shocks, given that these may be temporary. Secondly, innovation public policies may be targeted to certain regions or industries. In these cases, the cost of the information may vary according to those levels and they will be controlled. Lastly, in Bolivia between 2013 and 2015 there were only some public policies, as described in Foronda et al. (2018). There were no other programs that could bias disclosure of information on public programs.

A valid instrument has to satisfy the condition of significant correlation between instrument and endogenous variable. This condition may be tested by a significance test with the exogenous variable excluded from the first stage of regression. Stock, Wright, and Yogo (2002) recommend an F-statistic bigger than 10 to rule out a weak instrument problem, which may bias the sample in estimation by IV. In Table 4.1.1, it is observed that the F-statistic is equal to 12, which shows no evidence of the weak instrument problem. Besides, given that models exactly identified behave better with small samples, it is expected that the instrument chosen satisfies the relevant conditions and that the estimations have good properties in smaller samples (Harrison et al. 2014).

In Table 4.1.1, it is observed that estimation by IV increases the coefficient of g_2, which is consistent with a negative bias in the estimation by OLS. The estimation of coefficient of g_2 increases from 0.69 by OLS to 1.25 by IV. A coefficient greater than 1 is evidence that new products are manufactured less efficiently than existing products.[17] These results show that there is evidence that product innovation creates employment due to demand enlargement.

According to the table, the estimation by IV of the coefficient of process innovation (*d*) has a positive sign; however, the coefficient is not relevant, suggesting that process innovation has no significant effect on employment.[18] There are two possible explanations for this result: on the one hand, process innovation may not generate important productivity gains and therefore there is not a displacement of employment effect. On the other, process innovation may generate productivity gains (displacement effect), resulting in demand enlargement due to the competition of the market (creation effect). In general, the creation of employment effect compensates for the displacement of employment effect.

The Durbin–Wu–Hausman test is performed to evaluate the endogeneity of g_2. The exogeneity of g_2 is rejected at 10%. In general, for the estimated model estimation of IV is chosen, where g_2 is endogenous.

Table 4.1.1
Effect of innovation on qualified and unqualified employment: estimation of ordinary least squares and instrumental variables

Dependent variable: l -(g_1-π)	Total employment	Qualified employment	Unqualified employment
A) OLS			
Process innovators only (*d*)	-0,023	0,096	0,023
	(0,104)	*(0,190)*	*(0,125)*
Output growth due to new products (g_2)	0,690***	0,634***	0,763***
	(0,119)	*(0,147)*	*(0,193)*

[17] Results found in other countries (Crespi & Tacsir, 2013) show estimations for the coefficient of g_2 that range from 0.85 (by OLS) to 0.96 (by IV) for Uruguay and from 0.83 (by OLS) to 1.75 (by IV) for Chile.
[18] The same is true for coefficients of *d* for Argentina and Chile (Crespi & Tacsir, 2013).

R-square	0,230	0,141	0,136
B) IV			
Process innovators only (*d*)	0,154	0,336	0,152
	(0,141)	*(0,261)*	*(0,162)*
Output growth due to new products (g_2)	1,249***	1,385***	1,166***
	(0,313)	*(0,524)*	*(0,321)*
R-square	0,11	0,02	0,11
First stage (F-test)	11,73	11,91	11,91
P value	0,000	0,000	0,000
Test of endogeneity (Durbin–Wu–Hausman)	3,59	2,37	1,19
P value	0,061	0,123	0,275
H0: β = 1 (*p* value)	0,426	0,462	0,605
H0: βqualified = βunqualified (*p* value)	0,271		
Number of firms	422	422	422

Source: Science, Technology and Innovation Survey conducted in Bolivia in 2016.
Note: The table is based on the model in Harrison et al. (2014). Standard robust errors. All regressions are included as additional controls of a dichotomic variable with a value of 1 for those firms with more than 10% of foreign capital, a dichotomic variable with a value of 1 if the main office of the firm is located in the Department of Santa Cruz, and dichotomic variables of the industry at two digits. Qualified workers are employees with a university or tertiary degree (one- to three-year degree related to a technical profession). Unqualified workers are employees with primary or secondary education. The endogenous variable is g_2 and the instrument is knowledge of public support for innovation activities.
* Level of significance at 10%; ** level of significance at 5%; *** level of significance at 1%.

4.2. Innovation and employment qualification

This section presents the results of the estimation of equations (7) and (8). The dependent variables are rate of employment growth l type q_j minus rate of output growth $(l^q – (g_1 - \pi))$ for each type of employee (qualified and unqualified). Among the dependent variables are included the process innovation dichotomic variable, *d*, the rate of output growth of new products, g_2, a dichotomic variable that indicates whether the firm is located in the Department of Santa Cruz, and variables that capture the effects of the industry at two digits, as well as a constant that captures productivity tendency.

To understand the effect of innovation on qualified and unqualified employment is essential in the design of public policies. If innovation activities and qualified employment are complementary, the implementation of innovation is expected to generate more demand for qualified employment. This fact would justify implementing programs of training/employment and innovation policies simultaneously.

The results show interesting patterns of the impact of innovation on the composition of qualified and unqualified labor force. In columns 2 and 3 in Table 4.1.1, the results of the estimations by OLS and IV for qualified and unqualified employment are displayed. First, as expected, the estimated coefficients of g_2 and *d* by IV are bigger than those estimated by OLS. Second, the coefficient associated to output growth of new products is greater for qualified employment than for unqualified employment, as observed in Argentina and Uruguay, according to Crespi and Tacsir (2013). Third, the coefficients of process innovation *d* are positive (greater for qualified employment than for unqualified), but are not substantial. To sum up, there seems to be a bias in employment qualification for product innovation. These results are similar to the results obtained in Crespi and Tacsir (2013) for Argentina and Uruguay.

The results of the estimations by IV suggest that product innovations are intensive in qualified employment. The value of p of the test H_0: $\beta^C = \beta^{NC}$ is equal to 0.271. If H_1 means that there is bias in qualified employment, it is possible to reject the null hypotheses. There is no evidence suggesting that process innovation affects qualified or unqualified employment composition.

5. Robustness

In this section robustness tests are carried out to evaluate the sensitivity of the results of the effects of innovation on employment for different assumptions of the model, such as instruments' validity, alternative controls, and the exogeneity of innovation process.

5.1 Innovation and employment

Firstly, an additional instrument to test the exogeneity of the instruments is included, using the Sargan–Hansen test for overidentification. The additional instrument is an indicator (dichotomic variable) of continuous investment in R+D for each year (from 2013 to 2015). If R+D is correlated to the attributes of the firm that do not vary over time (which can be controlled in a way) instead of productivity shocks, the continuous R+D satisfies the assumption of exogeneity. Given the definition of continuous R+D, it is complex to assume its exogeneity. Column 1 of Table 5.1 presents results of the estimation of the overidentification model. The Sargan-Hansen test does not reject the exogeneity of the instruments. This result provides additional evidence for the validity of the instrument chosen.

Secondly, the model is estimated under the assumption that g_2 and the process innovation variable are endogenous. In column 2 of Table 5.1 the results of the estimation are presented. The estimation of the coefficient of the process innovation variable is significantly less precise. However, the estimation of coefficient g_2 is similar to the previous estimation, which assumes the exogeneity of process innovation. Moreover, the Durbin–Wu–Hausman test does not reject the exogeneity of the dichotomic variable of process and product innovation.

Thirdly, whether process innovation differs from process and product innovation is evaluated. To do so, the interaction between g_2 and process and product innovation is added. This new variable is considered endogenous, so the interaction between the variables of knowledge of support for innovation activities and process and product innovation are used as additional instruments. Column 3 of Table 5.1 presents the results of the estimation. The coefficient of g_2 has changed its sign; however, this is not relevant. It can thus be concluded that there is no significant evidence for considering process and product innovation separately.

Then, the model is controlled by industry shocks/location, including average employment growth at the level of the industry/location as an additional regressor. The basic model is controlled by specific shocks of the industry using dichotomic variables for the industry at two digits and controlled by specific location shocks using dichotomic variables of location. To control by using industry/location shocks, data obtained from the three departments are used (La Paz, Cochabamba, and Santa Cruz). Then, the average employment growth at the level of the industry and region is calculated. It is expected that this variable will be able to capture specific shocks of the industry/location. In column 4 of Table 5.1 a variable that is not significant is observed and the results are similar to those of the basic model.

Lastly, considering that endogeneity comes from unobserved productivity, workforce productivity is included as *proxy* of such. The variable *proxy* for unobserved productivity is workforce productivity in 2013, which is defined as real output per worker. In column 5 of Table 5.1 the variable is not significant and the results are similar to those of the basic model.

Table 5.1 Robustness tests for effect of innovation on employment

Dependent variable: l -(g_1-π)	[1]	[2]	[3]	[4]	[5]
Process innovators only (*d*)	0164	-0,141	0,014	0,158	0,143
	(0,137)	*(1,406)*	*(0,156)*	*(0,141)*	*(0,137)*
Output growth of new products (g_2)	1,282***	1,246***	-1,512	1,257***	1,228***
	(0,299)	*(0,317)*	*(7,600)*	*(0,312)*	*(0,305)*
g_2* products and process innovators (g_2*prod&proc)			3,289		
			(8,054)		
Average employment growth				0,091***	
				(0,033)	
Workforce productivity in 2013					0,057
					(0,036)
R-square	0,10	0,10	0,10	0,11	0,13
First stage of g_2 (F-test)	11,31	10,24	45,12	10,38	10,48
P value	0,000	0,000	0,000	0,000	0,000
First stage for *d*		1,96			
P value		0,050			
First stage for g_2*prod&proc			56,73		
P value			0,000		
Test of overidentification (Sargan–Hansen)	0,039				
P value	0,844				
Test of endogeneity for g_2 (Durbin–Wu–Hausman)	3,622	5,990	0,007	3,738	3,329
P value	0,057	0,015	0,934	0,054	0,069
Test of endogeneity for *d*		0,056			
P value		0,829			
Test of endogeneity for g_2*prod&proc			0,616		
P value			0,433		
H0: β = 1 (*p* value)	0,352	0,437	0,741	0,408	0,454
H0: β prod&proc = β only products (*p* value)			0,681		
Number of firms	422	422	422	422	422

Source: Science, Technology and Innovation Survey conducted in Bolivia in 2016.
Notes: Standard robust errors. All regressions are include as additional controls a dichotomic variable with value 1 for those firms with more than 10% of foreign capital, a dichotomic value of 1 if the main office of the firm is located in the Department of Santa Cruz, and dichotomic variables of the industry at two digits.
[1] The endogenous variable is g_2 and the instruments are knowledge of public support to innovation activities and a dichotomic variable for continuous R+D.
[2] The endogenous variables are g_2 and *d* and the instruments are knowledge of public support for innovation activities and a dichotomic variable for continous R+D.
[3] The endogenous variables are g_2 and g_2 x product and process innovator, and the instruments are knowledge of public support for innovation activities and knowledge of public support for innovation activities x product and process innovator.
[4] The endogenous variable is g_2 and the instrument is knowledge of public support for innovation activities. Additional controls are the average growth of employment at the industrial and regional levels.
[5] The endogenous variables is g_2 and the instruments are knowledge of public support for innovation activities. An additional control is work activity of the firm in 2013.
* Level of significance at 10%; ** level of significance at 5%; *** level of significance al 1%.

5.2. Innovation and employment qualification

In Table 5.2 the results from robustness tests are presented to evaluate the sensitivity of the effects of innovation on the composition of qualified and unqualified employment.

In the first place, the variable R+D is included as an additional instrument, though again the effect of process innovation is not relevant. The effect of product innovation is the same on qualified and unqualified employment. This result contradicts the bias of qualified employment when knowledge of public support is used as the only variable (considered the best specification of the model). The fact that different instruments show different results when rejecting overidentification of qualified employment may be interpreted in two ways. Firstly, if a choice between the two instruments is necessary, the exogeneity of knowledge of public support is preferred, as explained in the section's empirical results. Secondly, if the effect of innovation is heterogeneous among firms, even when both instruments are equally valid, the difference between the two is related to the fact that estimation by IV measures the local effect on the ones fulfilling the condition (Crespi & Tacsir, 2013)

Additionally, tests including different regressors were performed, in particular those mentioned in the reference list about specialized technical changes in developing countries (for example, Meschi, Taymaz, & Vivarelli, 2011). These include the logarithm of exports and the logarithm of fixed capital investments. Exports captures the improvement effect on the capacities of export activities (learning by exporting) and fixed capital investment captures the technological transfer that is implicit in physical capital. The results, presented in Table 5.2, show that these new variables are not relevant and the results do not change.

Table 5.2 Robustness test of the effect of innovation on qualified and unqualified employment

Dependent variable: l -(g_1-π)	[1]		[2]	
	Qualified	Unqualified	Qualified	Unqualified
Process innovators only (*d*)	0,314	0,209	0,333	0,126
	(0,231)	*(0,166)*	*(0,272)*	*(0,168)*
Output growth of new products (g_2)	1,316***	1,344***	1,382***	1,150***
	(0,432)	*(0,349)*	*(0,536)*	*(0,319)*
Exports in 2013 (log)			0,001	0,013
			(0,009)	*(0,014)*
Investment in physical capital in 2013 (log)			0,001	0,011
			(0,008)	*(0,009)*
R-square	0,044	0,08	0,02	0,12
First stage (F-test)	11,45	11,45	10,23	10,23
P value	0,000	0,000	0,000	0,000
Test of overidentification (Sargan–Hansen)	0,078	0,508		
P value	0,780	0,476		
Test of endogeneity for g_2 (Durbin–Wu–Hausman)	2,416	1,869	2,352	1,265
P value	0,120	0,172	0,126	0,261
H0: β = 1 (*p* value)	0,475	0,429	0,476	0,637
H0: βqualified = βunqualified (*p* value)				
Number of firms	422	422	422	422

Source: Science, Technology and Innovation Survey conducted in Bolivia in 2016.
Note: Standard robust errors. All regressions are include as additional controls a dichotomic variable with value 1 for those firms with more than 10% of foreign capital, a dichotomic value of 1 if the main office of the firm is located in the Department of Santa Cruz ,and dichotomic variables of the industry at two digits. Qualified workers are employees with a university or tertiary degree (one- to three-year degree related to a technical profession). Unqualified workers are employees with primary or secondary education.
[1] The endogenous variable is g_2 and the instruments are knowledge of public support for innovation activities and a dichotomic variable for continous R+D.
[2] The endogenous variable is g_2 and the instrument is knowledge of public support for innovation

activities. Additional controls are exports in 2013 (on record), imports in 2013 (on records, and transfer of technology in 2013 (on records).
* Level of significance at 10%; ** level of significance at 5%; *** level of significance at 1%.

6. Qualified and unqualified employment growth

With the purpose of better understanding the results of the estimations, the decomposition of the effect of innovation on employment growth is introduced using four components: productivity tendency, contribution of noninnovative firms, contribution of process innovators, and contribution of product innovators. This decomposition is similar to that proposed by Harrison et al. (2014) and adapted by Elejalde et al. (2015), and includes contribution of noninnovative firms and type of employment created (qualified and unqualified). Employment growth for each type of firm may be represented as

(9)

$$l_i = \left(\sum_j \alpha_j \, indy_{ji} + \sum_k \alpha_k \, depto_{ki}\right) + 1(g_{2i} = 0)(1 - d_i)(g_{1i} - \pi_i) + d_i 1(g_{2i} = 0)(\alpha_1 + g_{1i} - \pi_i) + 1(g_{2i} > 0)(d_i\alpha_1 + g_{1i} - \pi_i + \beta g_{2i}) + v_i$$

where $indy_{ji}$ are dichotomic variables of the industry and $depto_{ki}$ are dichotomic variables that denote the region where the firm's main office is located. Firm growth may be decomposed into four components: the first $\left(\sum_j \alpha_j \, indy_{ji} + \sum_k \alpha_k \, depto_{ki}\right)$ is the contribution of productivity tendency, the second $(1(g_{2i} = 0)(1 - d_i)(g_{1i} - \pi_i))$ measures the contribution of noninnovative firms, the third $(d_i 1(g_{2i} = 0)(\alpha_1 + g_{1i} - \pi_i))$ measures the contribution of process innovators only, and the fourth $(1(g_{2i} > 0)(d_i\alpha_1 + g_{1i} - \pi_i + \beta g_{2i}))$ measures the innovation of product innovators.

In Table 6.1 the contribution of different components to employment growth using estimations by IV is presented. The contribution of the productivity tendency associated to the manufacture of existing products is -15%, usually associated to the destruction of employment, as has been observed in LAC countries, according to Crespi and Tacsir (2013).

The contribution of noninnovative firms is -2% and, like the productivity tendency, its contribution to employment growth is negative. The contribution of process innovators to employment growth is only 1%. This explains in part the fact that few firms report having implemented process innovation only (9% of the sample).

The contribution to employment growth by product innovators is the most significant (31%). The result shows that product innovation and the manufacture of new goods and services compensate for the decrease in the manufacture of existing products. This takes place mainly in a context of economic expansion like that which Bolivia experienced between 2013 and 2015. As previously discussed, average output growth increases 33% for product innovators and 22% for noninnovative firms. The results show that product innovators considerably increase output of new products, but it should kept in mind that in many cases these new products consist of existing products with some minor alterations (incremental innovation), as Elejalde et al. (2015) suggest.

As observed in columns 2 and 3 of Table 6.1, the productivity tendency destroys employment, but the displacement effect is bigger in the case of qualified employment (-22%) than in the case of unqualified employment (-11%). It is also observed that, even though the percentages are smaller, the destruction of employment is similar in noninnovative firms for qualified and unqualified employment (-2%).

The contribution of process innovators is positive and small. However, the contribution to the creation of employment by product innovators is substantial, both for qualified employment (36%) and for unqualified (29%).

Table 6.1 Contributions of innovation to employment growth (annual rates of growth 2013–2015, %)

	Total (1)	Qualified (2)	Unqualified (3)
Employment growth in firms	0,14	0,15	0,17
Productivity tendency	-0,15	-0,22	-0,11
Contribution of noninnovators	-0,02	-0,02	-0,02
Contribution of process innovators	0,01	0,03	0,01
Contribution of product innovators	0,31	0,36	0,29

Source: Science, Technology and Innovation Survey conducted in Bolivia in 2016.

7. Conclusions

During the period under study (2013–2015), Bolivia experienced significant economic growth, around 5% of GDP. However, the country currently faces the challenge of growing sustainably and narrowing the gap of poverty and inequality. After COVID-19, when estimates are predicting a decrease in growth not seen in three decades, the challenge has become much more daunting.[19]

One of the key aspects of boosting productivity and sustaining economic growth is related to how firms implement technological innovation in their manufacturing processes (Foronda et al., 2018). Therefore, it is essential to understand the effects of technological innovation on employment creation, which consequently will reduce poverty and inequality.

The results of an estimation that relates technological innovation and employment creation are presented in this paper, using the original approximation of Harrison et al. (2014) and some data from LAC countries (Crespi & Tacsir, 2013). The Science, Technology and Innovation Survey conducted in Bolivia in 2016 was also used for this study.

During the period under study, it is noteworthy that product innovative firms increased their workforce productivity by 15%, whereas process innovative firms increased workforce productivity by 6% and noninnovative firms by 4%.Considering that the best results were obtained by innovative firms, these may be better prepared to withstand negative shocks in the economy, as well as the setbacks arising from the pandemics. Innovative firms (mainly product innovators) may have a stronger capacity to overcome negative shocks, and therefore it would be beneficial for the country to develop policies that incentivize firms to acquire those characteristics.

It is remarkable how fast product innovative firms substitute for their existing products. A decrease in the output of existing products (-25%) is compensated for by a significant increase in the output of new products (62%). However, the estimation of the increase in output of new products (g_2) and employment creation shows a coefficient greater than 1; hence, new products are manufactured less efficiently than existing products. The results prove that product innovation creates employment due to demand enlargement.

The main result of the present research is the contribution to employment growth by product innovative firms of 31%, far greater than that of all other types of firms. As observed in Table 6.1, the differences in terms of creation (or destruction) of employment between noninnovative firms and process innovators are noteworthy. This result also confirms that product innovations and creation of new or improved products compensate for the destruction of existing products, mainly in a scenario of economic expansion. For instance, output increased more for product innovative firms than for noninnovative firms (33% vs 22%). However, even though product innovators considerably increased their output of new products, in developing countries like Bolivia these new products turn out to be existing products with minor alterations. Moreover, in Bolivia 74% of innovations are carried out at the firm level, 24% at the country level, and only 2% at the world, as noted in Foronda et al. (2018).

The growth in workforce productivity may therefore be mostly related to incremental

[19] In April of 2020, the International Monetary Fund (IMF) forecast a 2.9% decrease in growth for Bolivia for the year. The last time Bolivia experienced a decline of comparable magnitude was in 1986 (-2.6%).

changes to existing products. The results show that training-labor policies are required to improve the skills of workers related to the manufacturing of existing products. Moreover, workers who gain experience with innovation techniques being implemented in firms have a high probability of applying those techniques in the future in an economy that is gradually undergoing technological change.

Based on the available data from Bolivia, process innovation has no statistically significant effect on employment, as other studies of developed countries and other LAC countries have found. This may be due, in part, to the fact that only few firms are process innovators and thus may not generate significant productivity gains on a broad scale, so that there is not a displacement effect.[20] Another possible explanation is that the displacement effect is compensated for by the employment creation effect due to demand enlargement.

From the estimations obtained, it is observed that the coefficient associated to output growth of new products (g_2) is larger for qualified employment than for unqualified. When broken out by type of employment, it is also observed that the coefficients of process innovation (d) are positive (larger for qualified employment than for unqualified) but not relevant, To sum up, qualified employment has a more prominent role in firms that are product innovators, which at the same time contribute more to the creation of employment in general. The results may serve as an impetus for public policies to support those types of firms. Though innovation may simply take the form of marginal changes applied to existing products, firms that innovate may be better positioned to overcome negative shocks and contribute significantly to economic growth, albeit mainly during periods of economic expansion.

It is evident that the effects of innovation on employment depend on the type of innovation implemented by the firm. Due to the fact that innovation may considerably vary across economic sectors, it should be assumed that the effects of innovation may also be different across sectors. Likewise, regulations of the labor market may have different effects, depending on the size of the firm. Large firms may avoid labor rigidities by outsourcing a portion of their productive sectors, an option smaller firms are less likely to have. On the other hand, small firms in LAC countries are more informal with respect to labor. Heterogeneity may have relevant political implications. In future work and surveys, the sample selection should be wide enough so that the effects of innovation on employment can be analyzed according to the size of firm, type of technology, and other similar factors.

Finally, together with any initiative to increase innovation, policy designers may find information related to the effects of such policies on employment relevant to answering the question of whether workforce reduction may be a consequence of innovation. In turn, ways of mitigating the potential costs of these effects may be sought until the manufacture of new and improved products increases demand, as has been observed in some developed countries (Harrison et al., 2014). Some strategies may include mitigation of the risk of unemployment by protecting workers affected by such changes through training policies that will enable the acquisition of skills more suitable to new work environments.

[20] Foronda et al. (2018) find that the workforce productivity of firms in Bolivia increases when firms implement product and process innovations. When decomposed into the two types, the most important effect on employment comes from process innovators.

8. References

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Annex

Table A.1
Exploratory regressions, estimation by ordinary least square

Dependent variable: l (Employment growth)	[1]	[2]	[3]
Constant	0,149**	0,154***	0,150**
	(0,076)	*(0,076)*	*(0,077)*
Process innovators only (not product innovators)	- 0,048	- 0,048	
	(0,072)	*(0,072)*	
Product innovators only (not process innovators)	- 0,066		- 0,066
	(0,044)		*(0.044)*
Product and process innovators	- 0,017		
	(0,061)		
Product innovators		- 0,045	
		(0,041)	
Process innovators			- 0,027
			(0,051)
Real output growth (g-π)	0,292***	0,292***	0,293***
	(0,049)	*(0,049)*	*(0,049)*
Foreign capital	0,131	0,137	0,135
	(0,130)	*(0,129)*	*(0,127)*
Located in Dept. of Santa Cruz	Sí	Sí	Sí
Dichotomic var. – Economic sector	Sí	Sí	Sí
R-square	0,191	0,190	0,190
Number of firms	422	422	422

Source: Science, Technology and Innovation Survey conducted in Bolivia in 2016.
Note: Standard robust errors. All regressions are include as additional controls a dichotomic variable with value 1 for those firms with more than 10% of foreign capital, a dichotomic value of 1 if the main office of the firm is located in the Department of Santa Cruz, and dichotomic variables of the industry at two digits. A product innovator is a firm that has implemented at least one product innovation, and a process innovator is a firm that has implemented at least one process innovation.
* Level of significance at 10%; ** level of significance at 5%; *** level of significance at 1%.