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# Unlocking Employability: Key Determinants for Industrial Engineering Graduates in Bolivia

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## Abstract

The employability of university graduates is an increasingly significant topic within educational and economic contexts. In particular, the employability of industrial engineering graduates in Bolivia represents a crucial area of study for comprehending the factors influencing their transition into the labor market. A comprehensive study was conducted utilizing a binomial logistic regression model to illuminate this issue. This model facilitated the estimation of the probability of unemployment among industrial engineering graduates by considering various predictor variables. The evaluated factors included postgraduate studies, gender, and the campus of study, all of which impacted employability significantly. The results identified the key determinants affecting employment and demonstrated a strong fit for the model, illustrating its effectiveness in accurately predicting unemployment probabilities. Specifically, the study indicated that students pursuing graduate programs often delay their entry into the labor market to secure better future opportunities. Additionally, a notable a non-conventional gender disparity was observed, with women exhibiting a higher probability of employment compared to men. Furthermore, the analysis of geographically separated universities revealed disparities in employment rates, underscoring the importance of location and academic environment as critical factors in employability. Thus, this research provides a comprehensive overview of the elements influencing the employability of industrial engineers in Bolivia, offering valuable insights that can inform the development of educational strategies and policies to enhance job opportunities for future professionals in this field.

## Keywords

Employability, Industrial Engineering, Bolivia, Logistic Regression, and Unemployment predictors.

## 1. Introduction

The world will need approximately 600 million job positions to absorb the workforce by 2030 (World Bank 2019). Employability refers to a set of transferable skills and qualifications that strengthen people's ability to use education and training to secure and retain decent work, financially progress, and adapt to labor conditions (Brewer 2013; Sarkar et al.2016). Thus, employability remains a pillar of sustainable growth and human development, influencing the nation's overall progress. For instance, in populated countries such as China and India, fluctuations in employment

rates are significant explainers of economic growth (Zhiwen & van der Heijden 2008). Hence, the successful incorporation of graduates into the labor market can be translated into a country's capacity to respond to modern challenges and demands, foster innovation, reduce poverty, and sustainably grow a productive workforce. Additionally, the modern landscape requires a scope of technological adaptation.

Today, nations need a competitive workforce understood as highly trained and prepared for the challenges of cutting-edge technologies and the so-called Fourth Industrial Revolution (Xu et al. 2019). The influence of digital transformations and the tendency to adapt flexibly to market dynamics has reshaped the work world. In this regard, careers in science, technology, engineering, and mathematics (STEM) have become relevant to competitiveness and innovation capabilities (Hernández-de-Menéndez et al., 2019). Professionals with versatile technical and managerial competencies are now expected to fulfill roles that respond to the rapid technological transformations of the modern digital era (Sakhapov & Absalyamova 2018; Alper & Alper 2020). This challenge is more pronounced in underdeveloped spheres where regional development disparities and insufficient academic resource allocation persist. Thus, manufacturing expansion and economic progress in these underdeveloped settings are closely tied to technological and skill sets in STEM education and training (Szirmai & Verspagen 2015).

Bolivia stands out among underdeveloped countries, requiring targeted efforts to improve employability in engineering careers. Due to its condition as a landlocked nation with the highest levels of multidimensional poverty and labor informality in South America (Herbas-Torrico et al. 2022; OPHI & UNDP 2024). Furthermore, within the diverse related fields of engineering, industrial engineering holds promise for sustainable progress in countries like Bolivia that consistently lack industrial infrastructure and manufacturing competitiveness (Boom-Cárcamo & Peñabaena-Niebles 2022). The present study examines the multivariate employability determinants among Bolivian industrial engineering graduates in response to these dynamics. By integrating insights through quantitative modeling, our research bridges the gap between academic training and labor market requirements (Sakhapov & Absalyamova, 2018). Additionally, we contribute to a deeper understanding of how educational frameworks must evolve to remain relevant and pertinent to promote employability (Ullah 2023).

In summary, employability increasingly relies on the professional's capacity for continuous learning, adaptability, and proactive career management (Laetitia & Rodrigues 2014). Thus, strengthening engineering education with practical preparedness and regional inclusivity becomes a strategic priority. However, there is a significant gap in empirical studies in Latin American contexts, particularly in countries like Bolivia. In these settings, structural, cultural, and social conditions pose unique challenges to the labor market integration of young professionals (ILO 2024). Understanding the dynamics that affect employability in these environments allows for adequate improvements in educational quality (Mashiyane et al. 2023). Our proposal promotes the design of effective public policies and institutional strategies to empower human capital.

This study addresses the employability gap by analyzing determinants of employability among Bolivia's industrial engineering graduates. Applying a binomial logistic regression model, we identified the variables influencing the likelihood of unemployment, including gender, postgraduate studies, work readiness, and city of study. Among the most notable findings, it was observed that women are more likely to find work. At the same time, those with postgraduate studies have acquired better job opportunities. Furthermore, significant disparities were evident between different regions, highlighting the impact of the academic and geographical environment on access to employment. Finally, adequate job readiness increases employment likelihood. By offering concrete and contextualized evidence, this research contributes to understanding employability in Bolivian industrial engineering, proposing a practical reference framework for universities, decision-makers, and stakeholders in the productive sector committed to developing engineering talent in emerging contexts.

## 1.1 Objective

This study aims to identify and analyze the key determinants influencing the employability of industrial engineering graduates in Bolivia; consequently, we bridge the gap between academic training and labor market demands. Specifically, our main objectives were (1) to assess the sociodemographic and academic, including gender, postgraduate education, and job readiness on the likelihood of unemployment, (2) to evaluate the role of geographical factors measured through the city of study or campus in shaping employability, (3) develop a predictive model applying the binomial logistic regression.

# 2. Literature Review

## 2.1. Employability status

Over time, employability has become crucial for graduates to adapt to changes and remain competitive in the modern labor market. Employability is defined in terms of technical or qualified skills and personal attributes such as adaptability, intrinsic motivation, self-regulation, and problem-solving capabilities, allowing competencies for career progression (McQuaid & Lindsay 2005; Rothwell & Arnold 2007). Thus, higher education institutions address students' qualifications adequacy for the future technological demands of the workforce (Baytiyeh & Naja 2012). Also, employability is influenced by various factors, including gender disparities (Ranasinghe et al. 2024), spatial and transportation accessibility for working (Merlin, 2016), the relevance of postgraduate education (Winberg et al., 2020), and the student's readiness for the workplace (Pais-Monte et al. 2019). Moreover, technological advancements demand engineering staff to be coupled with modern competencies such as robotics, artificial intelligence, data analytics, and advanced manufacturing (Kim et al. 2022).

## 2.2. Gender

Gender has long impacted job opportunities and how capabilities are perceived, delineating professional career paths and earnings disparities. Conventionally, culture and gender norms restrict women's access to specific roles, influencing hiring decisions (Ridgeway 2011). However, the last century saw a revolutionary shift in the workplace for women, challenging these stereotypes and driving positive change (Goldin 2006). This shift led to what Goldin (2006, 2014) called a quiet revolution as a consequence of women's active participation in economic roles shaped by long-term career involvement rather than just jobs. These advances led to a convergence between men's and women's labor force participation, work hours, occupations, college majors, and education (Goldin 2014). In the 1970s and 1980s, women narrowed the gender gap in science and math courses, later, participation rates for women of almost all ages, education levels, and marital statuses leveled off since 1990 (Goldin 2006). Surprisingly, the data from our study reveal that women now exhibit higher probabilities of attaining employee status. These trends challenge the conventional view that structural barriers systematically hinder women's labor market integration. Instead, formal employment structures became suitable for women due to the proliferation of diversity policies, flexible work arrangements, and the increased social valuation of women's labor (Eagly & Carli 2007). Furthermore, as women have overtaken men in educational attainment, entering diverse occupational fields, their representation in stable, contract-based employment may reflect the fruits of long-term social investment and evolving gender norms (Sarsons, 2024).

## 2.3. Study City

The study city is understood as the location where students complete their education. After graduation, the environmental conditions in the specific geographic spaces shape the job opportunities. This is related to the fact that more economically dynamic and diverse urban centers offer spaces for labor entry (Delgado 2020). There are differences and advantages in labor markets with more industrially developed national regions (Mason et al., 2009; He et al., 2018). Furthermore, cities with developed infrastructure and public logistic services favor labor transition (Bennett et al., 2008; Bastiaanssen et al. 2020). Together, these environmental arrangements facilitate the diffusion of professional networks and educational institutions (Delgado et al. 2010; Chakraborty 2024). Hence, the presence of industrial clusters co-located in ecosystems reinforces employment support and companies' presence (Lambert et al. 2017; He et al. 2018). Furthermore, the location of innovation and production in knowledge-intensive clusters strengthens the alignment between graduates' skills and labor market needs (Delgado, 2020). Mason et al. (2020) emphasize that those studying in economically developed cities with ample resources are better positioned to succeed in the job market.

## 2.4. Postgraduate studies

Postgraduate studies are presented as key factors to improve the employability of graduates in engineering, as they directly address the training gaps in the field (Nawab et al. 2020). The transition to a more industrialized economy requires highly specialized professionals, and postgraduate studies such as specializations, master's, and doctoral degrees align with the signaling theory proposed by Spence (1973). According to this theory, postgraduate education is a signal that validates specific competencies, such as technological management, production optimization, and industrial leadership, which are highly demanded by manufacturing sectors. In this context, advanced training contributes to reducing the skills gap (Iyer & Dave 2015), improving professionals' capacity to meet the needs of the industrial sector and positively impacting the country's economy. Through their advanced education, these professionals implement productivity improvements and possess skills in project management, strategic decision-

making, and leadership (Saikia, More, & Dur Khan 2022). Thus, postgraduate studies serve as a fundamental link between academic training and employability and are essential for the industrialization process and their quality.

### 2.5. Readiness for work

The concept of job readiness is a precursor to employability. It encompasses the development of practical skills that enable graduates to integrate academic knowledge with the demands of new work environments. Job readiness represents a process of internalizing a professional role, maintaining high motivation levels, and applying acquired skills (Kapareliotis et al. 2019). Therefore, individuals who perceive themselves as well-prepared are more likely to gain employment and progress in their careers (Hillage & Pollard 1998). This perception of self-efficacy is further reinforced by a connection through a strong curriculum design (Misni et al. 2020; Römgens et al. 2019). For example, curricula integrating practical components, such as internships and fieldwork, bridge the gap between theoretical learning and professional demands, boosting overall employability competencies (Misni et al. 2020). Furthermore, work-based learning initiatives, or experiential learning, have been shown to complement the development of the technical and interpersonal skills necessary for job placement (Kenny et al. 2016; Yuliyanto et al. 2024). These perspectives emphasize that adequate job preparation is essential for a smooth transition to professional life, which ultimately influences graduates' opportunities and long-term career development.

## 3. Methods

### 3.1 Conceptual framework and hypothesis

Based on the previous literature review, we developed a conceptual framework to examine the factors that influence the employability of university graduates. As illustrated in Figure 1, the model groups these factors into three main categories: sociodemographic, academic, and readiness. This structure is based on previous empirical research highlighting the relevance of individual characteristics and institutional support mechanisms in shaping employment outcomes (Fugate et al. 2004; Caballero et al. 2014; Rodríguez-Esteban et al. 2019). Our framework proposes four hypotheses (H1-H4): H1 postulates that gender positively influences employability; H2 suggests that studying in less economically dynamic cities hinders job opportunities; H3 indicates that postgraduate education increases the probability of employment, and H4 hypothesizes that readiness for work positively impacts employability. This model provides a structured view of the factors that explain graduates' successful transition into the labor market.

#### 3.1.1 Gender

Gender influences how people access, incorporate, and progress in the labor market. Traditionally, gender roles and structural inequalities have influenced employment outcomes in underdeveloped contexts such as Bolivia (Bue et al., 2022). However, over the past few decades, there have been significant reductions in gender discrimination, profound changes in women's rights, and a substantial increase in women's participation in the workforce (Goldin 2023). Also, the growing emphasis on diversity and gender equality within organizations has led to environments that positively impact women's employability (Kowalewska 2023). Today, inclusive hiring practices, career mentoring, and flexible work arrangements are common in work environments (Cavapozzi et al. 2021). Studies also show that gender-responsive support systems and egalitarian attitudes improve employability by facilitating smoother transitions from higher education to the labor market (Cavapozzi et al. 2021). Institutional and cultural advancements in Latin America have significantly reduced gender gaps in education and employment access.

Young women are already outperforming men in educational attainment, and most countries in the region have implemented regulations prohibiting gender discrimination in hiring (Bando 2019). These more just legal frameworks are associated with narrower gaps in vulnerable employment (Bue et al. 2022). Furthermore, women tend to be employed in service and ICT-intensive sectors, such as health and education, where accelerated digitalization has catalyzed their labor market insertion (Galperin & Arcidiacono 2021). Therefore, while gender disparities persist, favorable gender dynamics have contributed to greater female participation in the labor market. In this sense, we propose the hypothesis that gender positively influences employability. Inclusion and equity open new avenues for integration and professional advancement between genders.

***H1:*** *Woman-gendered professionals are more likely to have an employee status.*

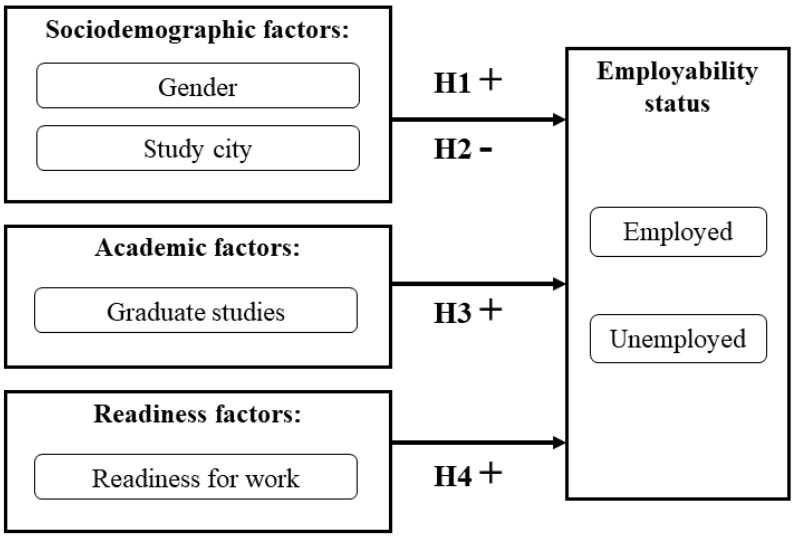


Figure 1. Conceptual framework and hypothesis

### 3.1.2 Study city

The development of graduates' geographic location is a crucial factor influencing job opportunities. Bolivia concentrates economic and industrial activity in specific urban centers. Big cities such as Santa Cruz, La Paz, and Cochabamba dominate the national economic landscape. However, Santa Cruz is the principal contributor to the national gross domestic product (GDP). Santa Cruz alone accounted for approximately 36.78% of the national GDP in 2023, while La Paz and Cochabamba contributed 27.30% and 14.82%, respectively (INE 2023). The other departments contributed less than 7%. Hence, the larger and populated urban centers like Santa Cruz generate a higher demand for a skilled workforce (INE 2024). These big cities concentrate industries and advanced infrastructure, offering job seekers competitive advantages (Bennett et al. 2018).

Furthermore, access to prestigious universities, training centers, and professional networks in these spaces facilitates graduates' transition from academia to the workforce (McGunagle & Zizka 2020). Delgado (2020) argues that educational institutions and robust economic activity create a propitious ecosystem for job preparation. As a consequence, graduates residing in or schooling in these economically less dynamic regions tend to face greater employment difficulties (Santos et al., 2021). Thus, the disparity in economic growth and industrial presence across urban environments reinforces the hypothesis that a graduate's geographic location is a key factor for employability.

***H2:*** *Less economically dynamic cities reduce the likelihood of employability.*

### 3.1.3 Postgraduation studies

Postgraduate studies improve graduates' employability prospects. Higher education affects employability by enhancing specialized knowledge, skills, and professional networks. As Bolivia's labor market becomes more competitive, the need for specialized knowledge and advanced skills is accentuated. Postgraduate programs encourage specialized internships and collaborations with industry, creating a match between advanced training and employer requirements. Employers thus favor candidates with advanced qualifications who can manage complex tasks and leadership roles (McGunagle & Zizka 2020; Nogales et al. 2020). Employers associate advanced degrees with greater problem-solving and critical-thinking skills (McGunagle & Zizka 2020; Santos et al.2021). Moreover, postgraduate studies signal candidates with specific competencies and commitment to career advancement (Spence 1973). This gives employers preference for candidates possessing higher education studies, which is linked with greater competence, resilience, and adaptability (Vasquez & Cedro 2024). Finally, postgraduate studies can lead to career progression and salary increases, incentivizing professionals to pursue higher education (Daniel et al. 2023). Therefore, postgraduate studies appear to increase the employability prospects of graduates.

***H3:*** *Postgraduate studies increase the likelihood of employability.*

### 3.1.4. Readiness for work

Employability goes beyond academic qualifications only; incorporating practical skills and an applicative approach is essential for the labor market. In Bolivia, employers increasingly prioritize candidates with practical experience and strong interpersonal skills (Vasquez & Cedro 2024). Complemented with adaptability, problem-solving ability, teamwork, and communication skills, readiness for work can significantly improve graduates' employability (Teng et al. 2019). Graduates who develop strong work readiness capabilities through internships, extracurricular activities, and practical experiences demonstrate a better fit with organizational needs (Vasquez & Cedro 2024). Employers often look for candidates who can quickly integrate into the work environment, demonstrate initiative, and rapidly understand the organization's dynamics. In particular, candidates require relevant experience and interpersonal abilities to resonate with the employer's expectations (Mahajan et al. 2022). Graduates from institutions with strong work-integrated learning programs are more likely to demonstrate greater work preparedness. Therefore, higher readiness for work is expected to improve employability outcomes.

**H4:** Readiness for work increases the likelihood of employability.

### 3.2 Sample, measures and data analysis

The study collected data from professionals who graduated from the Industrial Engineering program from private and public universities in different Bolivian cities. With the help and support of university authorities and a solid graduate contact network, we reached out to a diverse sample of graduate Industrial Engineers. After cleaning, a final sample comprised 2248 respondents, with the distribution shown in Table 1. Of this sample, 78.9% were employed professionals, and around 62.9% were women engineers. The sampled engineers performed jobs in various companies, sizes, and roles. A pilot test was conducted before the full implementation of the measurement questionnaire. Confidentiality was maintained for all participants, and their contributions were duly acknowledged. We processed all the data using the statistical software Jamovi (version 2.6.26; The jamovi project 2025).

The focal point of our analysis was implementing a binomial logistic regression model. The binomial logistic regression model allows the modeling of the relationship between independent predictors and a binary dependent variable, in this case, the employment status. It is a robust statistical technique and does not need compliance in multivariate normality and homoscedasticity assumptions (Tabachnick et al. 2014; Gaur & Gaur 2009). This technique was chosen not for predictive purposes but to identify and understand significant relational patterns and associations between explanatory variables and employability status.

The independent variables were selected based on previous studies determining the factors affecting employability among engineering careers, such as gender (Powell et al. 2009; Beede et al. 2011; Wang & Degol 2017), study region or city (Palgiara et al. 2013; Wright & Ellis 2019), postgraduation studies (Tomlinson 2012; Sarkar et al. 2016; Winberg et al. 2020), and readiness for work (Trevelyan 2019; Kolmos & Holgaard 2019; Deters et al. 2020). This approach provides a comprehensive view of the odds probabilities of employment and unemployment status of engineering graduates from Bolivia.

## 4. Data Collection

Our key variables, descriptive results, and characteristics from the data collected are shown in Table 1. Most respondents were employed, with 78.9%, and the remaining 21.1% were unemployed. Also, women represent a more significant portion of the respondents, around two-thirds of the population (62.9%). Additionally, the most important portion of respondents are from Santa Cruz city, with 37.3%, while the smallest corresponds to the city of La Paz (19.8%). Most of the respondents don´t have postgraduate studies (93.5%). Finally, the only continuous variable, readiness for work, had a mean of 7.35 and a standard deviation of 2.42, not complying with a normal distribution.

Table 1. Descriptive and baseline characteristics

| Variable | Frequency | % |
|---|---|---|
| ***Employment status*** | | |
| 1 = Employed | 1774 | 78.9% |
| 0 = Unemployed | 474 | 21.1% |
| ***Gender*** | | |
| 1 = Woman | 1415 | 62.9% |
| 0 = Man | 833 | 37.1% |
| ***Study city*** | | |
| 1 = La Paz | 445 | 19.8% |
| 2 = Cochabamba | 498 | 22.2% |
| 3 = Santa Cruz | 838 | 37.3% |
| 4 = Other states | 467 | 20.8% |
| ***Postgraduation studies*** | | |
| 1 = Yes | 146 | 6.5% |
| 0 = No | 2102 | 93.5% |
| ***Readiness for work**** | | |
| Mean | 7.35 | |
| Standard deviation | 2.42 | |
| Median | 8 | |
| Mode | 8 | |
| Min | 1 | |
| Max | 10 | |

* Kolmogorov-Smirnov and Shapiro-Wilk tests rejected normal distribution.

## 5. Results and Discussion

### 5.1 Results

Our global model test suggests that the binomial logistic regression model provides a statistically significant improvement over a null model ($p<0.001$) (view Table 2). This means that the model statistically explains the employability status of Industrial Engineering graduates. Furthermore, as expected in non-predictive relational models that address human and social dimensions, the model describes only a small portion of the variance in employability. Nevertheless, this contribution is statistically significant, and its relatively low pseudo-$R^2$ values ($R^2McF = 0.055$; $R^2CS = 0.0552$; $R^2N = 0.081$) are common in binomial logistic regression analyses dealing with social phenomena influenced by multiple factors (Hair et al., 2010; Tabachnick & Fidell, 2019).

Table 2. Model fit measures

| Comparison measures | | | Pseudo $R^2$ | | | Global model test | | |
|---|---|---|---|---|---|---|---|---|
| **Deviance** | **AIC** | **BIC** | **$R^2_{McF}$** | **$R^2_{CS}$** | **$R^2_N$** | **$\chi^2$** | **df** | **p** |
| 2196 | 2210 | 2250 | 0.055 | 0.0552 | 0.081 | 120 | 6 | < .001 |

The Omnibus Likelihood Ratio Test (table 3) assessed the contribution of the individual predictors. All predictors were statistically significant among their levels, contributing to employability prediction. Additionally, some assumption checks were done. Multicollinearity assessed with the VIF value had all values close to 1, meaning there was no multicollinearity issue in the model. Furthermore, the logistic regression model showed satisfactory overall performance, with an accuracy of 79.3% and statistically significant predictors. However, it also showed low specificity (5.9%) for identifying unemployed graduates. This result aligns with the pronounced class imbalance in the dependent variable, as most respondents reported being employed during the survey. In these cases, logistic models tend to favor the majority of the class. Consequently, this reduces the model's ability to detect minority outcomes, but it does not necessarily indicate poor model quality (Hair et al. 2010).

Table 3. Omnibus Likelihood Ratio Test

| Predictor | $\chi^2$ | df | p |
|---|---|---|---|
| ***Gender*** | 5.18 | 1 | 0.023 |
| ***Study city*** | 20.85 | 3 | < .001 |
| ***Postgraduation studies*** | 42.80 | 1 | < .001 |
| ***Readiness for work*** | 49.25 | 1 | < .001 |

Based on the abovementioned predictors, the model coefficients estimated the log odds of being employed versus unemployed (Table 4). The gender predictor signified that women had 1.29 times higher odds of being hired than men ($p<0.05$). Regarding the study city, graduating in Cochabamba, compared to Santa Cruz, is associated with lower employment odds, with (OR = 0.73, $p<0.05$), and those from other cities also had lower employment probabilities (OR = 0.65, $p<0.05$). Lastly, professionals who held a postgraduate degree had 3.39 times higher odds of being employed ($p<0.001$). Finally, the positive readiness for work increased the employment odds by 1.16 times ($p<0.001$). Thus, the results obtained indicate that the employability of industrial engineers in the Bolivian context is determined by a combination of social, academic and contextual elements.

Table 4. Model coefficients

| Predictor | Estimator | SE | z | p | Odds ratio |
|---|---|---|---|---|---|
| Constante | -0.82 | 0.24 | -3.39 | < .001 | 0.44 |
| ***Gender*** | | | | | |
| Woman – Man | 0.26 | 0.11 | 2.26 | 0.024 | 1.29 |
| ***Study state*** | | | | | |
| La Paz – Santa Cruz | 0.29 | 0.16 | 1.77 | 0.076 | 1.33 |
| Cochabamba – Santa Cruz | -0.28 | 0.14 | -2.00 | 0.046 | 0.75 |
| Other states – Santa Cruz | -0.41 | 0.14 | -2.94 | 0.003 | 0.66 |
| ***Postgraduation studies*** | | | | | |
| No – Yes | 1.22 | 0.18 | 6.76 | < .001 | 3.39 |

| | | | | | |
|---|---|---|---|---|---|
| ***Readiness for work*** | 0.15 | 0.021 | 7.09 | < .001 | 1.16 |

Note: The estimators represent the log odds of being 'Employed' compared to 'Unemployed' in terms of employability status

First, female graduates are more likely to find work than their male counterparts. This finding, consistent with previous studies (Galperin & Arcidiacono, 2021; Bue et al., 2022), suggests a transformation in traditional gender roles, driven by equity policies, improved female academic performance, and their growing presence in sectors such as services, healthcare, and technology (Goldin, 2014; Sarsons, 2024). However, this progress in job placement does not necessarily imply equality in employment conditions, so additional studies on quality, remuneration, and job stability are required. Second, graduates from less dynamic cities face greater difficulties accessing the labor market. Opportunities are concentrated in Santa Cruz, which leads the national GDP and has industrial infrastructure, professional networks, and better-equipped universities (Delgado 2020; Mason et al. 2009). This finding highlights the urgency of strengthening the link between universities in peripheral regions and the productive sector through internships, entrepreneurship incubators, and regionalized job placement programs. Third, having a postgraduate degree significantly improves the likelihood of employment, which aligns with Spence's (1973) signaling theory. This credential conveys to employers advanced skills in leadership, management, and problem-solving (Winberg et al. 2020; Saikia et al. 2022). However, it can also lead to delayed job placement in exchange for better prospects. Expanding access to postgraduate programs through scholarships, flexible modalities, and partnerships with productive sectors is recommended. Finally, self-perception of competencies and preparation for the workplace are key determinants of employability. Beyond technical knowledge, employers value soft skills, adaptability, and practical experience (Kapareliotis et al. 2020; Römgens et al. 2019). Universities must strengthen training strategies such as internships, active methodologies, and project-based learning that develop transversal skills from the formative stage.

Given the class imbalance identified previously, we investigated alternative methodologies to assess the robustness of our findings. Initially, we applied resampling strategies alongside model training, leading to consistent results with no significant changes in the hypothesized relationships. Subsequently, we employed classification methods, including random forest, which yielded outcomes comparable to those of the logistic regression analyses, without providing meaningful enhancements in predictive differentiation. Hence, the implementation of additional methodologies affirmed the robustness of our logistic regression outcomes. Future research could benefit from the implementation of other analytical methods. Among these alternatives, ensemble models or cost-sensitive learning can enhance class discrimination while maintaining model interpretability. Still, the current findings remain valuable in highlighting the key educational, social, and contextual variables that influence the employment status of Industrial Engineering graduates in an underdeveloped environment.

## 6. Conclusion

The transition from university to the workforce is crucial for graduates, defining not only their professional careers but also a country's overall economic and social development. In Bolivia, like many developing countries, industrial engineering drives sustainable growth. Understanding the factors that influence employability is more than an academic exercise; it is necessary to strengthen the workforce. Our study sheds light on these factors, offering insights that can help graduates, educators, and policymakers address the challenges of today's labor market. The study results made it possible to meet the proposed objectives and show that the variables analyzed significantly influence the employability of Industrial Engineering graduates in Bolivia. By applying a binary logistic regression model, it was possible to identify how gender, city of study, postgraduate training, and job preparation are key determinants of graduates' employment status.

First, a discrepancy was identified in the probability of being hired, where women attracted greater labor market insertion than their male counterparts. This can be interpreted as an indication of progressive change in the Bolivian industrial labor market due to social influences of equity and the growing appreciation of transversal skills in which women stand out, consistent with the study by Gokuladas (2011). Contrary to traditional human capital theory predictions (Beede et al.2011), our results show that female graduates exhibit 1.29 times higher employment odds than males. This aligns with Goldin's (2023) quiet revolution, where increased educational attainment and workplace flexibility policies have improved women's labor market outcomes. Secondly, regarding the city of study, it was evident that graduates from Santa Cruz have greater employment opportunities than those who studied in Cochabamba or other regions. This reflects the concentration of economic and industrial activity in that city and the need for

educational institutions to adjust their employability strategies according to local environmental characteristics. Therefore, the appropriate university-business linkage is highlighted, which, in this context, could reduce regional disparities in access to employment.

On the other hand, the analysis shows that professionals with postgraduate studies have a significantly higher probability of being hired. This result supports Spence's (1973) signaling theory and validates the hypothesis that advanced training programs act as qualification signals in the Bolivian labor market. The employability of graduates can be improved by providing them with the necessary tools in a postgraduate program (Kucel et al., 2016). Likewise, this training generates positive externalities for the industry by promoting innovation and attracting investment, which aligns with human capital theory. Finally, job preparation proved a determining factor, indicating the importance of developing competencies and values in graduates that prepare them to adapt and succeed in the work environment. This finding reinforces the importance of integrating pedagogical strategies to develop soft skills, practical experiences, and professional insertion initiatives during academic training.

Together, these results provide a comprehensive view of the factors affecting graduates' employability and establish baseline guidelines for future academic and institutional interventions to improve this population's labor market integration conditions. As a result, universities are beginning to incorporate innovative teaching methods and digital tools to simulate real-world production scenarios, thereby equipping students with the competencies needed to thrive in an Industry 4.0 paradigm (Kim et al. 2022). Improving the employability of industrial engineering graduates in Bolivia requires a multifaceted approach that addresses educational quality, regional disparities, and labor market alignment. By implementing evidence-based strategies, stakeholders can foster a more inclusive and competitive workforce, ultimately contributing to Bolivia's economic and industrial development.

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