# PROYECTOS EMPRESARIALES INDUSTRIALES

# INDUSTRIAL BUSINESS PROJECTS

# Future scenarios of the copper industry. A prospective study of the copper sector in Peru*

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ABSTRACT. Mining has led to multiple social conflicts between communities and companies. However, at the same time, it has been the activity with the greatest contribution to Peru's gross domestic product for more than a decade, especially copper mining. The importance of copper lies in the fact that it is one of the basic raw materials for the manufacture of products and the expansion of global industries. This research seeks to identify and analyze the possible behavioral scenarios that will support copper mining in the next five years. Foresight (projection of future scenarios), along with the judgment of experts in the field, was used for conducting the research. This methodology employs a non-experimental design and aims at both exploratory and descriptive results. The main findings include an increase in the electricity cost for mining and the continuation of an unfavorable political leadership for its development. It is clear that this issue is taking place in a sensitive context due to the constant social conflicts that occur in favor of the growth of industry. This study will undoubtedly propose solutions to this disparity and will research whether, in any scenario, copper mining and the total population of a copper-rich country can really coexist.

KEYWORDS: copper / copper mining / foresight / variable / scenario

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# ESCENARIOS FUTUROS DE LA INDUSTRIA CUPRÍFERA. UN ESTUDIO PROSPECTIVO DEL SECTOR EN EL PERÚ

RESUMEN. La minería ha generado múltiples conflictos sociales entre comunidades y empresas; sin embargo, ha sido la actividad con mayor contribución al producto interno bruto del Perú desde hace más de una década, sobre todo, la explotación cuprífera. La relevancia del cobre radica en que es una de las materias primas básicas en la fabricación de productos y la expansión de las industrias globales. A través de este artículo, se busca identificar y analizar los posibles escenarios de comportamiento de la minería cuprífera en los siguientes cinco años. Para el desarrollo del trabajo, se utilizó una prospectiva (proyección de escenarios a futuro) sumada al juicio de expertos en la materia. La metodología utilizada es el diseño no experimental y apunta a un resultado tanto exploratorio cuanto descriptivo. Entre los principales hallazgos, destacan un aumento del costo de la energía eléctrica para la actividad minera y la continuación de un manejo político desfavorable para su desarrollo. Es claro que este tema se desarrolla en un contexto delicado por los constantes conflictos sociales que se originan en pro del crecimiento de la industria. Sin duda, a raíz de este estudio, se podrán plantear soluciones a esta disparidad y a indagar si realmente, en algún escenario, podrán coexistir la actividad cuprífera y la población total de un país colmado de este mineral.

PALABRAS CLAVE: cobre / minería cuprífera / prospectiva / variable / escenario

## 1. INTRODUCTION

Copper, silver, and gold mining has been the cornerstone of the economic and sociocultural development of Andean societies for at least the last three millennia (Guédron et al., 2021). However, the first of these metals has not ceased to be important for the Peruvian nation even today. Thus, according to Hanni and Podestá (2019), copper is the mineral that has contributed the most foreign exchange to mining in Peru since it has accounted for about 23 % of the total exports in the last 10 years. Likewise, as mentioned by García and Pantigoso (2020), as of 2019, Peru has been the second largest copper producer (12 % of world production) with approximately 2,46 million tons. However, this positive outlook does not necessarily imply permanence; it is therefore essential to ask certain questions about the future context of the copper sector.

There are variables that have a significant impact on the stability and development of the Peruvian copper industry. Therefore, it is important to first determine which of them are exogenous and which are endogenous, then assess which features characterize them and, most importantly, see how they relate to each other (Andújar-Palao et al., 2021). The different interactions of these variables were considered in this research to visualize the future scenarios for copper industry in Peru and identify the most appropriate ones for its continuous development.

### 1.1 Rationale

Copper mining in Peru is one of the main drivers of the Peruvian economy. According to Landa Arroyo (2017), copper exports account for about 23 % of the country's total exports per year. Yet, from an environmental point of view, the population's discontent is growing because of the continuous and increasing presence of the mining industry, which in the country is often associated with phenomena such as environmental degradation, threat to native species, and harm to the lifestyle of surrounding villages. Likewise, the image of mining companies is often related to economic inequality and an unwillingness to redistribute wealth and development to the populations indirectly affected by this type of resource exploitation. However, regarding this point, Cornejo (2018) states that the main problem is the municipal and government management since the amounts of money contributed by mining fees are abysmal. Therefore, they are not used to improve health and education infrastructures and to repair the damage caused to the soil or to the standard of living of citizens and the environment; this situation does not end up being a responsibility and negligence of the mining company in question but rather a demonstration of the ineffectiveness of the political authorities.

Similarly, Landa Arroyo (2017) believes that this feature—the inefficient management of mining resources for the population—can be explained by two reasons. First, the State's lack of vision for sustainability, and second, the incipient and slow process of regionalization in Peru. Cornejo (2018) concluded that, despite the environmental impact of mining companies, they—in cooperation with the State—are working to remedy this situation. Likewise, there is evidence that, in formal mining, there is willingness to financially compensate those who have suffered negative consequences of the activity. On the contrary, mineral extraction operations that have the most negative impact on ecosystems and the lives of the inhabitants are the informal ones. Informal mining follows unregulated processes and disposes of its waste in an irresponsible manner, resulting in an aggressively polluting activity. The abundant presence of this activity in the country is mainly due to poor control, high mineral prices, and the lack of employment and State presence in rural areas.

Economically, Peru has experienced remarkable changes in the copper sector. The exploitation of minerals other than gold, such as copper, is striking. This fact is convenient based on the idea of Miguel Cardozo, Vice President of the Instituto de Ingenieros de Minas del Perú (IMP), who claimed in an interview with the "Red de Comunicación Regional del Perú" in 2021 that, the price of copper has increased by more than 70 % in the last 12 months, reaching even more than USD 4 a pound.

On the other hand, the demand for this mineral is expected to continue to grow with the addition of new sustainable energy technologies in the coming years (Kuipers et al., 2018). It is estimated that 1,74 million tons of copper will be used to manufacture electric vehicles, according to a research conducted by the International Copper Association in 2017. However, despite being the second largest producer worldwide, this will represent a product attrition in the country compared to 2030, as there will be a 20 % shortage in copper supply to meet the increased demand for the red metal, says Cardozo in the interview.

On the social aspect, mining in Peru has always been a focus of conflicts between the population and mining companies. According to the last report issued by the Ombudsman's Office of Peru in December 2021 (Instituto de Ingenieros de Minas del Perú, 2021), more than 200 social conflicts were registered per month, a figure not reached since 2018. Dunlap (2019) mentions that one of the projects with the greatest social impact in the country is the so-called "Tía María" (Valle del Tambo, Arequipa), which planned to extract 120 000 tons of refined copper per year through an investment of USD 1,4 billion and would last approximately 18 years. Dunlap (2019) states that the main reasons for the protests and conflicts that have occurred between Southern Copper Corporation and the people of Valle del Tambo have been the result of Southern's mismanagement. For example, groundwater pollution from tailings, even though they are used by the entire population for everyday purposes, and air pollution from PM2.5 and PM10, which can penetrate deep into the lungs and pose significant health risks, are attributed to the company's inappropriate waste management in the area.

### 1.2 Copper Industry in Peru

Based on a detailed review of several documents of the copper sector in Peru, the article *Minería del cobre en Perú: análisis de las variables exógenas y endógenas para gestionar su desarrollo* [*Copper Mining in Peru: Analysis of Exogenous and Endogenous Variables to Manage its Development*] (Andújar-Palao et al., 2021) will be one of the basic academic sources for this research. This document and others will help us simulate and analyze future scenarios for the Peruvian copper industry in relation to its internal and external variables. The internal or endogenous variables were the following: production efficiency, transport logistics efficiency, job creation, and energy supply. On the other hand, the external or exogenous variables were as follows: investment attractiveness, socio-environmental conflicts, China's demand, demand for sustainable economy, water availability, political leadership, geological potential, and price volatility.

For some internal variables, according to Vidal et. al (2019), production efficiency is determined through the management of different factors. These include labor costs, unit costs, new technologies, among others. In Latin America, labor costs tend to be relatively low. On the other hand, based on a report by the Mexican Center of International Relations in 2019, electricity cost in Peru ranks second in Latin America, with the most expensive electricity price ranging from USD 0,16 to 0,20 per kWh, only behind Uruguay, whose prices exceed USD 0,20 per kWh. Furthermore, this variable has a direct relationship with job creation in the country pursuant to the journal of the National Society of Mining, Oil and Energy of 2022, for this year, the mining sector would generate approximately 2,3 million new jobs due to the post-pandemic economic recovery of companies.

On the other hand, two of the aforementioned external variables are related to a significant impact on current and future copper mining. The first one is "political leadership." In the opinion of Andújar-Palao et al. (2021), Peruvian mining used to face two contexts: first, a government that rarely intervenes in dialogues or renegotiations with mining unions; and second, an endemic corruption in the sector. However, with the arrival of the new Peruvian president in 2021, who belongs to a left-wing party, it was assumed that the new government would get deeply involved in this sector. The objectives would be to control the mining fee and to reassess this economic activity's percentage received by both mining companies and the government. Naturally, this development is of concern to mining companies. Moreover, as is evident, a new government has an impact on the second variable, "investment attractiveness" since when a president with such characteristics begins his/her term of office, there is uncertainty among investors. This is due not only to the president's personal profile but also to the history of how left-wing leaders have traditionally influenced, with their measures, the economies of the countries of this region, especially in fundamental extractive activities such as mining.

Schipper et al. (2018) state that copper demand grew rapidly throughout the 20th century, and that there is no indication that this growth will slow down in the short term. For their study, the authors made an estimate of copper demand for year 2100, finding a range between 3 and 21 times the current copper demand. The difference between scenarios lies in fluctuations between population, gross domestic product (GDP), and renewable energy adoption. Lagos et al. (2020) reaffirm this idea, as they conclude that Chile would produce 143,7 million tons of copper between 2019 and 2035, below the 210 million tons of remaining reserves estimated by the United States Geological Service (USGS) in 2017. However, it should be clarified that it does not deny a decrease due to the current lack of knowledge about the projects that could be developed in the future.

On the other hand, all metals exist in finite reserves and resources on Earth (Sverdrup et al., 2019). As a result, a pertinent question would be whether this could become a long-term availability problem, especially given the demand for electrical products that use copper as main raw material. In their simulation, it was found that in the future, copper supply will be significantly higher than its primary production. Copper production is expected to peak by 2050 and decrease thereafter as a primary source. However, copper will be present in human societies long after copper mines are depleted, as it will be supplied through recycling and urban mining.

Within the technological context, Haas et al. (2020) conducted a research on seven of the world's largest copper mines. The objective was to design the energy supply based on solar and mineral storage technologies until 2050. The results suggested that all regions studied should already have solar generation of 25 to 50 % of the annual electricity demand in 2020. By 2030, sunny regions should enjoy an almost fully renewable supply, while regions with fewer solar resources will become predominantly solar by 2040. Additionally, Behar et al. (2021) indicated that incorporating solar energy into mining processes opens an opportunity to reduce the carbon footprint associated with mining activity. Upon completion of the research, the authors found that optimized changes in current operations to adapt the availability of solar resources could be an attractive solution for the massive incorporation of solar energy into mining.

As for the national level, Andújar-Palao et al. (2021) carried out an analysis and identification of those internal and external variables that manage the development of the copper industry in Peru, among which they included as endogenous: production efficiency, transport logistics efficiency, job creation, and energy supply; and as exogenous: investment attractiveness, socio-environmental conflicts, China's demand, demand for sustainable economy, water availability, political leadership, geological potential, and price volatility. Likewise, Gonzalez et al. (2019) classify Peru's climate conditions as an important external variable to consider since there are extreme rainfalls in the mining regions of the country, which could affect both the time and ease of overland transport of the mineral. In addition, they detail that weather would also influence the availability of water because part of the water resource from rainfalls is used for this industry. Thus, due to the fact that a possible reduction in the frequency of rainfalls is expected for the next few decades, it is assumed that this will imply a possible water scarcity in the country; as a result, mining would be affected and forced to increase its costs.

In terms of theoretical background, Elshkaki et al. (2018) projected a model with multiple scenarios of potential metal demand between 2010 and 2050. Under alternative global development patterns and using CMLCA software, they calculated the “cradle-to-door” environmental impacts (i.e., from the actual extraction of raw material to the output of the manufactured product) of producing 1 kg of each metal. On the other hand, Sverdrup et al. (2019), in their study of the long-term sustainability of copper, zinc, and lead, used the STELLA software, which differs from the STELLA software typically used to simulate life-cycle stages, as it was employed to simulate the dynamics of supply, demand, and market prices for these metals. Additionally, Gonzalez et al. (2019) used ETCCDI’s software to project the impact of extreme rainfalls in Peru. This program is traditionally employed for weather forecasting.

## 2. METHODOLOGY

This was a non-experimental, exploratory, and descriptive research. The key variables that condition the development of the copper industry in Peru were projected prospectively—through critical expert judgment and collective reflection—for the creation of future scenarios in the sector. This qualitative research methodology was based on four phases, which are detailed in Table 1 along with their scope, techniques, and tools.

**Table 1**

*Research Phases*

| Phase | Scope | Techniques | Tools |
|---|---|---|---|
| 1. Identification and validation of key variables for the system | Literature review for the identification, selection, and prioritization of key variables through expert interviews | Prioritization matrix<br>Expert interviews | Comparison table of variables<br>Interview guide |
| 2. Creation of future scenarios | Creation of future scenarios and outlining according to the probability of occurrence | Scenario simulation | Smic-Prob-Expert software |
| 3. Selection of the trend core and the most suitable scenarios | Interpretation of the most likely simulation scenarios and search for the most suitable ones | Scenario simulation | Pareto chart, focus group with experts |

(*continues*)

(*continued*)

| Phase | Scope | Techniques | Tools |
|---|---|---|---|
| 4. Prioritization of strategies to achieve the chosen scenarios | Strategy prioritization according to their probability of occurrence and validation with expert interviews | Strategy prioritization<br>Expert interviews | Importance and governance (IGO) matrix<br>Interview guide |

The first phase involved a literature review to identify the key variables of the country's copper sector and subsequently classify them. For this purpose, an extensive research was carried out in different databases such as Scopus and Web of Science. This review made it possible to confirm the variables with the greatest impact on the development of the mining industry since they were also found in the documents consulted. To determine the hierarchy of the aforementioned variables, a prioritization matrix (Casas Rivera & Giraldo Gómez, 2014)—i.e., a tool that allows organizing parameters according to their dependence and influence relationships—was used.

Once this matrix was prepared, the five most important and influential key variables were selected. This selection was validated with the input of five experts in the field through interview guides where they expressed their various points of view due to the decisions made in the previous matrix. The selected experts were representatives of the national and international mining industry (Table 2).

**Table 2**

*Expert Chart*

| Expert | Code | Years of Experience | Profile |
|---|---|---|---|
| 1 | E01 | 22 | Legal representative of one of the largest mining companies in the country. |
| 2 | E02 | 25 | Leader of one of the most long-standing mining companies. |
| 3 | E03 | 16 | Metallurgical engineer with experience in the copper sector. |
| 4 | E04 | 30 | Leader of a long-standing mining company. |
| 5 | E05 | 10 | Strategic partner of one of the mining companies in southern Peru. |

After defining, evaluating, and subsequently verifying the variables, a prospective study was conducted. The tools made it possible to organize and structure, in a clear and efficient manner, the joint reflection on current and future challenges. Furthermore, the prospect could also be used to evaluate strategic options (Godet, 2007). To this end, it was necessary to simulate the interaction between the determining variables with the specific tools for these case studies.

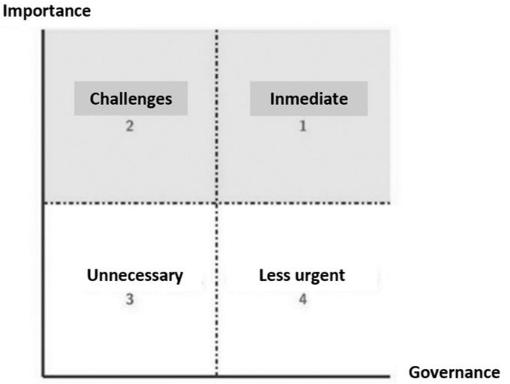
In the second phase, a probabilistic cross-impact method was used: the Smic-Prob-Expert software. This cross-impact method, according to Godet (2007), seeks to identify the most likely scenarios after performing morphological analyses and mixtures of hypotheses that would be preemptively excluded. Therefore, it aims to recognize the simple and conditional probabilities of hypotheses or events from the interrelation between them. The strategy may be the focus of attention once the scenarios composed of the interactions between the variables have been generated.

The third phase covered the interpretation of the scenarios with the highest probability of occurrence as a result of the simulation performed and the search for the most suitable ones. Ruiz Ruiz (2017) reinforced the concept of using the Smic-Prob-Expert software for the creation of future scenarios. Thanks to this reinforcement, it was decided to carry out the simulation using such software. Then a list of the potentially most beneficial scenarios for the Peruvian copper industry in the coming years was made. Finally, they were analyzed and ranked in order of priority and probability of occurrence.

For the fourth and final phase, strategy prioritization was made according to the probability of occurrence of the most convenient and beneficial scenarios using an IGO matrix (Figure 1). This matrix was used to identify strategic variables based on two criteria: importance and governance. Importance refers to the level of value of each variable to achieve a defined goal, while governance refers to the ability of decision-makers to act on a particular variable (Velasquez Lugo, 2020). In addition, following this analysis and ordering, the experts were interviewed, through the respective guides, to validate this prioritization and final probabilities assigned.

**Figure 1**

*Structure of an IGO Matrix*




*Note.* Adapted from Chalapud Narváez (2022)

## 3. RESULTS

The results of the research phases defined in the Methodology section are presented below. Table 3 shows the key variables identified from a systematic review of specialized literature and the validation of a group of experts with extensive experience in the mining sector.

**Table 3**

*Scope of the Evolution or Current Situation*

| Variable | Scope of the Evolution and/or Current Situation |
|---|---|
| V1. Production Efficiency<br>It refers to dealing with different factors such as labor, unit costs, and the use of new technologies, among others. In Latin America, overall, labor costs are relatively cheap. | As stated by Banco Central de Reserva del Perú (BCRP), Peru, in particular, has been one of the countries with the highest productivity growth in the region over the past decade, showing an average total factor productivity (TFP) growth of 2,6 % per year, second only to Panama. |
| V2. Electricity Cost<br>It is linked to the cost of electricity needed to conduct copper industry operations in the country. The nature of this variable is based on the expenses originated by energy consumption according to the required production. | Since 2019, Peru ranks second in Latin America in terms of electricity cost, with USD 0,16 to 0,20 per kWh. Moreover, an increase from the current price is expected in the next five to seven years. |
| V3. China's Demand<br>It refers to the annual needs of the world's largest copper consumer. China's demand is key, as they currently account for 70,4% of Peru's copper exports. | Out of the USD 2 274 million produced by Peruvian mining between January and July, USD 295 million came from Chinese capital. These were mainly used for the Toromocho project expansion in Junín. |
| V4. Political Leadership<br>It refers to the political situation of each country and how the ideological beliefs of those in power influence the context of each economic sector. | Pursuant to a survey conducted by IEP, 62 % of Peruvians disapproved the administration of President Pedro Castillo and only 38 % supported his work. In central and southern regions of the country, Pedro Castillo had his highest approval rate. The indicator used would be the governor's approval survey. |
| V5. Investment Attractiveness<br>It is defined as opportunities where there are minimal or no risks. It is closely related to the political context of each country. | Peru's country risk index fell seven basis points to 1,77 percentage points. According to investment bank J. P. Morgan, Peru registered the lowest country risk in the region with 1,77 percentage points. |

As a result, five events were proposed for a five-year time horizon. These projections are based on the five key variables identified.

1. Event 1: Probability that production efficiency will increase by 30 %.
2. Event 2: Probability that the electricity cost will increase by 30 %.
3. Event 3: Probability that China's domestic copper demand to Peru will increase by 10 %.
4. Event 4: Probability that the political leadership will remain unfavorable.
5. Event 5: Probability that investment attractiveness will continue to increase.

In a first stage, the experts were consulted on the probability of occurrence of such events as a simple probability, i.e., assuming individually the relevance of each event to the whole. Subsequently, work was done on cross-conditional probabilities (positive and negative) since the context in this area involves several factors that are not necessarily mutually exclusive.

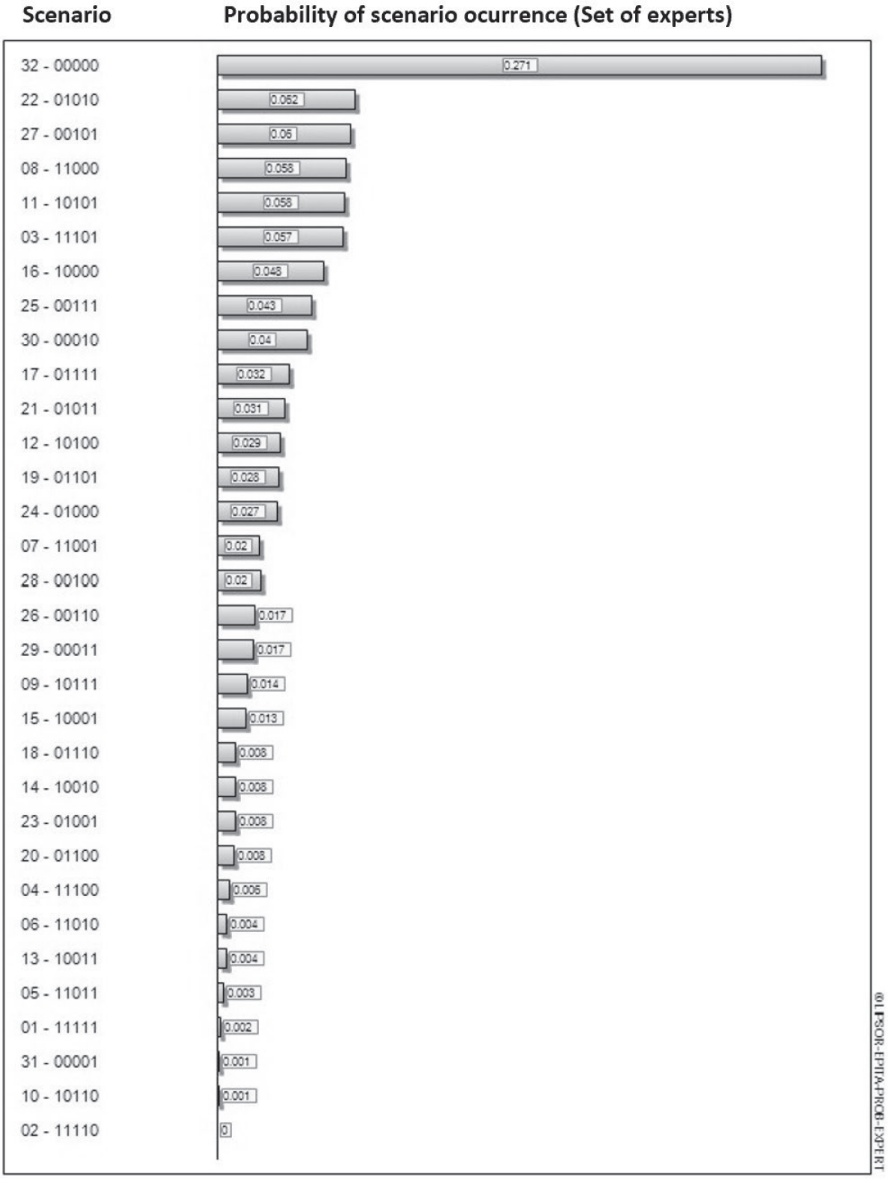
Once the probability of occurrence of the above events had been defined, the probability form was filled in. The objective was to collect in an organized manner the information and conclusions provided by the specialists. Once the responses were recorded on the forms, the marked probabilities were entered into the Smic-Prob-Expert software. From this process, the possible scenarios were projected. Finally, the result was verified by the experts following—in addition to their knowledge—their extensive experience in the mining industry.

According to the combination of probabilities, 32 scenarios with different probabilities of occurrence were created. This would be assigned by the same algorithm used by the software when crossing the aforementioned conditions. The sum of probabilities distributed among the 32 scenarios had to be one or, in percentage terms, 100 %. The higher the number assigned by the software, the greater the probability of that scenario to occur. Also, the lower the number assigned, the lower the probability of occurrence. If the number is zero, the scenario would simply not happen.

In accordance with the Pareto Principle, the scenarios that accumulate approximately 80 % probability of occurrence were considered. Twelve of the 32 scenarios were thus selected. This set of 12 scenarios is known as the trend core. However, for the purposes of the research, the five scenarios with highest probability of occurrence were prioritized, based on the results obtained with the Smic-Prob-Expert software. This prioritization aimed at validating the probability of an event and its impact on the industry through the opinion of the experts interviewed. It should also be noted that each scenario was composed of the probability of occurrence of the proposed events pursuant to the key variables.

**Figure 2**

*Histogram of Potential Future Scenarios for the Copper Industry (1/2)*




As can be seen in Table 4, 78,9 % of the probability of occurrence corresponds to 12 of the simulated scenarios, with scenario 32 being the most probable and scenario 12 the least probable.

**Table 4**

*Cumulative Probability of the Trend Group Scenarios*

| Scenario | Probability | Cumulative |
|---|---|---|
| 32 (0000) | 27,1 % | 27,1 % |
| 22 (01010) | 6,2 % | 33,3 % |
| 27 (00101) | 6,0 % | 39,3 % |
| 8 (11000) | 5,7 % | 45,1 % |
| 11 (10101) | 5,8 % | 50,9 % |
| 3 (11101) | 5,7 % | 56,6 % |
| 16 (10000) | 4,8 % | 61,4 % |
| 25 (00111) | 4,3 % | 65,7 % |
| 30 (00010) | 4,0 % | 69,7 % |
| 17 (0111) | 3,2 % | 72,9 % |
| 21 (01011) | 3,1 % | 76,0 % |
| 12 (10100) | 2,9 % | 78,9 % |
| Total | - | 78,9 % |

According to the above, scenario 22 and 27 were the most likely to occur after the least desired scenario (scenario 32). Scenario 22 was qualified by experts as a negative impact on the political and energy context and scenario 27 as China's Imperial Glory. Each of them is presented below.

### *Negative Impact on the Political and Energy Context (Scenario 22)*

Scenario 22, also known as "Negative Impact on the Political and Energy Context," is the one in which the probability of a 30 % increase in electricity cost (E2) and the probability that the political leadership remains unfavorable (E4) are met. Experts agree that this scenario will be the most likely due to the country's current situation, political instability, constant confrontation with the country's mining companies, and the instability of the Peruvian currency against the US dollar. Social actors, such as the population that opposes mining projects and political parties that use this feeling of opposition as a means of campaigning, hinder mining growth.

### *China's Imperial Glory (Scenario 27)*

On the other hand, scenario 27, defined as "China's Imperial Glory," is made up of the probability that Chinese copper demand for Peru will increase by 10 % (E3) and the probability that investment attractiveness will continue to increase (E5). This scenario turns out to be the second most likely as indicated by the software. It involves, as social actors, China's and Peru's economic growth. The introduction of new sustainable technologies, based on copper mining, will undoubtedly make Peru one of the most viable countries to exploit this resource.

Upon completion of the research phase, a scorecard was prepared to assess the importance and governance of the events established according to the abovementioned variables. This tool makes it possible to visualize the events that would have greater relevance in the prospective study proposed and to complement the results obtained by the opinion of experts in the field.

**Table 5**

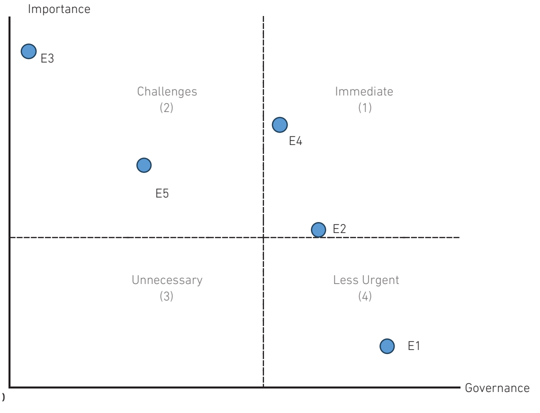
*Event Scorecard*

| Events | | Assessment | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Importance | | | | Governance | | | |
| | | 1 | 2 | 3 | 4 | 0 | 1 | 3 | 5 |
| E1 | Probability that production efficiency will increase by 30 % | | X | | | | | | X |
| E2 | Probability that the electricity cost will increase by 30 % | | | X | | | | X | |
| E3 | Probability that China's domestic copper demand to Peru will increase by 10 % | | | | X | X | | | |
| E4 | Probability that the political leadership will remain unfavorable | | | | X | | | X | |
| E5 | Probability that investment attractiveness will continue to increase | | | | X | | X | | |

Subsequently, and given that the priority of these events is sought, they were distributed in a matrix consisting of four blocks. The criterion is based on its level of importance and governance found in the scorecard. The five events ranked in the IGO matrix are presented below.

**Figure 3**

*Application of an IGO Matrix*




Based on the results in Figure 3, events 2 and 4 were classified as "immediate." This suggests that they will play an important role in the future of the copper industry. On the other hand, it is also worth noting events 3 and 5, which are classified as "challenges." This suggests that although they are not dominant at all, they do have a significant degree that could generate relevant discussion in the future.

### *"Pessimistic" Scenario as the Most Likely: On the Probability that None of the Events Will Occur*

As scenario 32 ("pessimistic") has the highest probability of occurrence, it can be understood that none of the events will likely occur in conjunction with another. The possible achievements of these are recorded as simple probabilities of occurrence; however, when it comes to generating cross-probability scenarios, the absence of any scenario involving two or more of the selected events is considered more likely. Expert opinion was also divided in both simple and cross probabilities. Nevertheless, below this "pessimistic" scenario (27,1 % probability of occurrence) are scenario 22 (6,2 % probability of occurrence) and scenario 27 (6 % probability of occurrence). Still, the nearly 20 % higher probability gap with respect to other scenarios makes the difference quite clear.

### Event 2: On the Probability that the Electricity Cost Will Increase

When analyzing the scenarios with higher probability of occurrence, it could be observed that there was less uncertainty regarding the increase in electricity cost for the next five years. According to Haas et al. (2020), in recent years, the electricity sector has experienced an odd bifurcation of interests. On the one hand, electricity wholesale price has continued to fall to levels of inability to invest. On the other hand, the electricity bill to end users has continued to rise, except perhaps for large loads. Likewise, as previously confirmed, Peru ranks second in electricity cost per country in the region with USD 0,20 per kWh. As a result of this data and its influence, a stronger opinion among experts may be that the electricity cost will continue to rise slightly in the coming years before achieving some stability.

#### Event 4: On the Probability that the Political Leadership Will Remain Unfavorable

Just as the probability of an increase in the electricity cost was identified, the scenario involving the continuation of an unfavorable political leadership was also discussed by the choice of experts. In the opinion of expert 2 (E02), this would be a recurrent scenario due to the existing social injustice and the marked differences between the country's social classes and regions. As a result of these differences, political leaders, who are elected only because they present a vindictive agenda, delay or hinder the progress of mining activity. E02 also mentioned the persistence of social conflicts between socioeconomically disadvantaged populations and large operating mining companies. This opinion was complemented by that of Instituto de Ingenieros de Minas del Perú (2021). This institution refers to the latest report issued by the Ombudsman's Office of Peru in December 2021, which recorded more than 200 social conflicts per year. On the other hand, expert 5 (E05) contradicted this fact by mentioning that, once the current administration is over, the election of a left-wing ruler is unlikely to be repeated. E05 supports his/her opinion on the results of the current mandate and the dissatisfaction felt toward the president by the vast majority of the national population, including underprivileged groups.

#### Event 3: On the Probability that China's Domestic Copper Demand to Peru Will Increase by 10 %

When analyzing scenario 27, it was found that, among the experts surveyed, there is a relatively low uncertainty regarding this event since they think that this demand will continue to grow over time. Expert 4 (E04) stated that "China's copper demand will increase exponentially for at least the next 5 to 10 years due to the growing need for technology, as it uses copper components in multiple cases." Likewise, the Instituto de Ingenieros de Minas del Perú (2022) considers that, until about 2026, copper demand will outstrip supply. However, from 2027 onwards, it is believed that there will be a supply surplus versus demand. In this likely context, Peru should make efforts to attract foreign capital to focus on and increase copper reserves. Thus, by the period between 2025 and 2030, profits and development could be exploited and generated as a result of high mineral prices.

#### Event 5: On the Probability that Investment Attractiveness Will Continue to Increase

Likewise, for scenario 27, the increase in investment attractiveness remained slightly more uncertain than China's Domestic Copper Demand to Peru (expert 3 - E03). According to expert 1 (E01), Peru is considered attractive for foreign investment. Although there has been some uncertainty among investors at the start of the incoming government, the positive and attractive image is expected to continue to increase, due to the constant growth of the mining activity in the country. As explained by Hunt et al. (2021), mining in 2021 accounted for almost 64 % of total exports and contributed to Peru's GDP by 9,7 %. In addition, in terms of the mining fee, historic figures were reached for the following regions: Ancash (PEN 2 086 millions), Arequipa (PEN 1 118 millions), Tacna (PEN 840 millions), Ica (PEN 828 millions), and Moquegua (PEN 575 millions).

## 4. CONCLUSION

The results of this research show the future changes that copper mining could undergo in the next five years. Among the main findings, it is foreseen that there will be a slight increase in the electricity price and the continuation of a political leadership that represses the development of this activity. Likewise, it was identified that China's copper demand to Peru will grow as well as the investment attractiveness in the country. These findings are represented by scenarios 22 and 27. Everything indicates that, although political opposition and indirect manufacturing costs, such as electricity, will rise mining production costs, the increase in demand and investment attractiveness will compensate these drawbacks and could even produce more profits than those currently generated. However, these are only predictions subject to common events, which could be changed by the occurrence of outliers.

These results were limited to the Peruvian context and the possible political projection given its current situation. In 2023, Peru is still undergoing political instability and social conflicts. This creates uncertainty for foreign investors and large-scale mining operations, which involve large financial and time investments that generate generous contributions to the Peruvian economy. It should also be noted that the events mentioned in this study could be affected by this uncertainty and the multiple probabilities of the outcome of the Peruvian socio-political conflict and therefore create scenarios different from those mentioned before.

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