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From Orica to Peru: Advancing Industrial Development through Innovation, Safety, and Sustainable Growth

Abstract*– Peru's recent growth is closely tied to mining, where copper and associated mineral exports shape output and public revenues. In this context, explosives providers such as Orica play an enabling yet largely invisible role in productivity, safety and environmental outcomes. This paper examines how Orica's operations in Peru contribute to industrial development through three dimensions: technological innovation in blasting, safety and risk management, and sustainable growth. Using a qualitative case study design based on corporate reports, industry analyses and national statistics, the study connects company initiatives with macro indicators of mining dependence on gross domestic product and exports. The first-dimension analyses digital blasting ecosystems, advanced bulk explosives and wireless initiation systems that seek to optimize fragmentation, reduce unplanned stoppages and improve energy efficiency along the mining value chain. The second examines how frameworks such as ISO 31000 and safety culture research are translated into training, procedures and digital monitoring to prevent fatalities, high potential incidents and occupational exposures. The third explores Orica's decarbonization trajectory, including recent double digit reductions in net scope one and two greenhouse gas emissions and a forty five per cent reduction target for twenty thirty, together with efforts to reduce nitrate leaching and water use. By situating these practices within a copper dependent and socially demanding development model, the paper argues that blasting can evolve from a cost line item into a strategic lever for competitiveness, resilience and more responsible resource development.

***Keywords*- Industrial development, Innovation, Safety, Sustainable growth, Mining industry.**

I. Introduction

Peru's recent growth pattern remains tightly coupled to the performance of its mining sector, where copper and associated mineral exports dominate merchandise trade and shape fiscal space, regional employment and industrial linkages. In this context, explosives and blasting services are usually treated as an operational cost at the pit, yet they strongly influence downstream productivity, energy use and the environmental footprint of open pit operations. When blasting is poorly designed or executed, mines face oversize fragmentation, higher energy consumption in comminution, unplanned stoppages and increased safety risks; conversely, systematic improvements in blast design can cascade through loading, hauling and processing, with economy-wide implications in a country where mining exports account for a substantial share of output.

At the same time, global pressures for safer and greener mining are reshaping expectations for suppliers. Reviews of emerging green mining technologies argue that more efficient resource use, lower emissions and reduced waste are becoming sources of competitive advantage, not only responses to regulatory mandates, with explosives and blasting identified as critical levers for decarbonization and energy efficiency across the value chain [1].

In parallel, studies of safety culture in mining show that accident prevention depends not only on technical controls but also on shared attitudes, norms and learning behaviors, underscoring the need to integrate digital blasting, remote operations and data-rich incident analysis into wider organizational cultures [2].

Risk management frameworks provide a further layer of structure for aligning innovation, safety and sustainability. Recent work on ISO 31000 in Latin America highlights how continuous, cyclic risk processes and clear criteria can help organizations embed risk considerations into day-to-day decisions rather than treating them as a parallel compliance exercise [3].

For a specialized supplier such as Orica, which operates at the intersection of blasting technology, on-site safety and environmental performance, these frameworks shape how innovation is translated into operational practice in complex mining environments like Peru.

Against this backdrop, the present study examines how Orica's Peruvian operations contribute to industrial development through three interrelated dimensions: technological innovation in blasting, safety and risk management, and sustainable growth. By combining corporate and industry documents with national statistics, the article situates Orica's digital platforms, advanced explosives and risk frameworks within Peru's broader pattern of mining dependence and development challenges. The analysis seeks to show how a blasting provider can evolve from a narrow cost line item into a strategic partner for competitiveness, resilience and low-carbon industrial growth in a resource-dependent economy.

II. Literature Review

The link between mining and industrial development in Peru has been documented for decades, yet recent data underscore how concentrated this relationship remains in a few commodities. According to recent investment and trade summaries, mining accounts for around eight and a half per cent

of Peru's gross domestic product and mineral exports represent close to sixty four per cent of total exports, with copper ores and concentrates alone exceeding thirteen billion United States dollars in export value in 2022. This pattern of concentration magnifies the relevance of productivity, safety and environmental performance in large open pit operations, where explosives and blasting design determine downstream efficiency in loading, hauling and crushing.

Technical research on blasting has moved well beyond empirical rules of thumb toward numerical simulation and soft computing tools. [4] present a soft computing framework to optimize rock fragmentation in quarries, integrating blasting parameters, rock properties and desired fragment size distributions, and demonstrate that carefully calibrated models can reduce oversize boulders and improve downstream energy efficiency. [5] apply numerical modelling of blast induced rock fragmentation to show how changes in burden, spacing and charge distribution affect crack propagation and fragment size, highlighting the potential of simulation to support pre blast decision making. Xia and collaborators examine water decked blasting and find that appropriate water placement can improve fragmentation while simultaneously reducing vibration, fly rock and air overpressure, which directly connects blasting design with environmental and community risk. Together, these contributions frame blasting as an engineering science where digital modelling and sensor feedback can meaningfully increase the quality and predictability of outcomes.

Parallel to the technical literature, researchers have begun to map the implications of digitalization for mining value chains. Reviews of Mining four point zero and related initiatives describe how integrated data platforms, remote monitoring and analytics move critical decisions away from isolated operators toward coordinated, data informed teams. In blasting this is reflected in electronic detonators with precise timing, automated bulk explosives delivery systems and cloud based design tools that link geology, drill and blast, and processing. Case material on Orica's digital blasting platform in Latin America illustrates this shift: solutions such as BlastIQ, FRAGTrack and the four dimensional bulk system allow mine operators to adjust energy distribution by hole and by bench in response to geology, while capturing data across hundreds of blasts each week. These tools convert blasting into a controllable and optimizable process rather than a necessary disruption.

Safety culture and risk management form the second major strand of the literature. [2] conduct a retrospective analysis of occupational health and safety reports in mining and show how the framing of safety culture influences both accident investigation and the design of preventive interventions. They identify themes related to attitudes, norms and competence, emphasizing that technical controls are insufficient if organizational culture does not promote learning and accountability. Other empirical studies link strong safety cultures with lower incident rates and sustained operational performance in industrial settings, suggesting that safety practices can be treated as capabilities rather than mere compliance obligations.

Risk management standards offer a complementary institutional lens. The ISO 31000 framework has become a reference for integrated risk management in both public and private organizations, particularly in Latin America. [3] review advances in ISO 31000 implementation and highlight how continuous, cyclic risk processes, clear criteria and stakeholder communication create better conditions for managing strategic, operational and compliance risks. Lizarzaburu and colleagues provide a more specific contribution by analyzing how organizations in Latin American countries adapt ISO 31000 to their local context, underscoring that embedding risk management into daily operations improves resilience and supports long term sustainability. work by Lizarzaburu and co authors on the ISO 31000 framework for enterprise risk management shows how risk maps and governance structures can connect risk appetite, internal controls and strategic decision making [6].

Corporate governance in mining adds a financial dimension to these operational and risk considerations. In a recent study focused on Peru, Lizarzaburu and collaborators construct portfolios of mining companies listed on the Lima Stock Exchange and find that firms with higher adherence to good governance principles exhibit better risk adjusted stock performance than peers with weaker governance practices. Their results suggest that investors in mining markets assign tangible value to transparent governance and compliance, which aligns with global trends in environmental, social and governance integration. For suppliers like Orica, this implies that safety, environmental performance and responsible business conduct are not peripheral but central to the expectations of their mining clients and the broader capital market [6].

Sustainable mining and green technology represent the third cluster of contributions relevant for this case. [1] review emerging green mining technologies and practices and argue that more efficient resource use, lower emissions and reduced waste generation are increasingly linked to competitive advantage, not only to regulatory pressure. Their analysis stresses the importance of energy efficiency, low emission explosives, improved ventilation and real time monitoring for decarbonization pathways in mines. Parallel work in global commodity dependence shows that countries reliant on mineral exports, such as Peru, must couple productivity gains with social and environmental safeguards if they are to escape volatility traps and achieve inclusive development.

Taking these strands together, the literature suggests that explosives and blasting services can shape industrial development in three main ways. First, digital and analytical advances in blasting improve productivity, reduce variability and enhance the contribution of mining to gross domestic product and exports. Second, integrated risk management and safety culture frameworks, including those developed by Lizarzaburu for Latin American organizations, support safer

operations and more robust governance, which in turn affect capital allocation and stakeholder trust. Third, green technologies and decarbonization strategies position mining regions and their supply chains to align with climate commitments and evolving expectations from global customers and local communities. This conceptual foundation frames the analysis of Orica's role in Peru's industrial development that follows [6].

III. Methodology

The study adopts an exploratory qualitative case study design that integrates corporate, industry and macroeconomic sources in order to capture how Orica's blasting and explosives operations in Peru support innovation, safety and sustainable growth. The unit of analysis is the set of Orica activities that directly serve Peruvian mining operations, particularly large scale open pit copper and polymetallic mines, over the period from 2015 to 2024. This period is chosen because it coincides with the consolidation of electronic detonators in Peru, the introduction of digital blasting platforms in Latin America and the articulation of quantified climate and decarbonization commitments by Orica at global level.

Data collection proceeded in three stages. The first stage focused on company level information. Annual reports, climate action reports and environmental, social and governance data packs from Orica were reviewed to extract indicators related to greenhouse gas emissions, energy use, safety performance, R and D expenditure and statements about digital blasting and product innovation, with emphasis on Latin American and Peruvian operations where available. Industry interviews and profiles in specialized mining publications, including International Mining and Global Business Reports, were then examined to contextualize how Orica's Peruvian leadership describes its priorities in terms of innovation, safety and sustainability [7], [8].

The second stage assembled macroeconomic and sectoral data to situate Orica's activities within Peru's industrial structure. Statistics on the share of mining and industry in gross domestic product, as well as the weight of mineral exports in total merchandise exports, were obtained from World Bank World Development Indicators, the World Integrated Trade Solution database, the Central Reserve Bank of Peru and recent investment guides prepared by EY and Peruvian authorities [9], [10]. Additional descriptive information on copper production volumes and export destinations was collected from specialized trade and commodity reports.

The third stage linked these two layers through analytical categories derived from the literature review. Three categories were used. The first category, innovation and productivity, captured digital blasting tools, advanced explosives formulations and related impacts on fragmentation, cycle time and ore recovery. The second category, safety and risk management, focused on safety indicators, risk management frameworks and references to ISO 31000 and safety culture in both Orica and mining company materials, interpreted in light of academic studies by Lizarzaburu and other authors [6]. The third category, sustainable growth, encompassed greenhouse gas emissions, energy intensity, water use, waste and the deployment of green technologies and process improvements in blasting, connected to country level climate and development agendas.

The analysis combined document coding with descriptive statistics. Corporate and industry documents were coded manually according to the three categories, paying particular attention to references to Peru and Latin America. This coding allowed identification of recurring themes, such as the emphasis on WebGen wireless initiation, four dimensional bulk explosives and predictive fragmentation analytics in Peruvian open pit operations. Macroeconomic data were summarized in a table that links the contribution of mining to gross domestic product and exports with Orica's reported emissions trajectories and targets. On this basis, a simple comparative graphic is proposed to visualize the relative magnitude of these indicators and their potential implications for Peru's industrial development.

Although the study relies entirely on secondary sources, methodological rigor is pursued by privileging peer reviewed journals, official statistics and corporate disclosures subject to external assurance or regulatory scrutiny. All references included in the paper correspond to identifiable publications with digital object identifiers or official links, and care is taken to avoid sources that cannot be verified. In line with the literature on risk management and governance, particular attention is paid to contributions by Lizarzaburu and co authors, given their focus on Latin American organizations, mining companies in Peru and ISO 31000 integration. The limitations of a single case study are acknowledged in the concluding section, yet the richness of the combined data provides a robust narrative of how an explosives and blasting company can act as a catalyst for innovation, safety and sustainable industrial growth in a resource dependent economy [6].

IV. Results and Discussion

The results are organized following the three analytical categories introduced in the methodology: innovation and productivity, safety and risk management, and sustainable growth. For each category the findings from Orica's corporate and industry disclosures are interpreted in light of macroeconomic data and the academic literature on blasting, risk management and green mining.

A. Innovation and productivity in Peru's blasting operations

Peru's economic profile reveals the centrality of minerals for its external accounts. World Bank trade and production data show that copper ores and concentrates occupy the first position in Peru's merchandise exports, with values above thirteen billion United States dollars in 2022, followed by unwrought gold and liquefied natural gas [11]. Complementary estimates based on EY's mining and metals investment guides indicate that mining contributes around eight and a half per cent of gross domestic product and mineral exports account for roughly sixty

three point nine per cent of total exports. In this context, any systematic efficiency gain in blasting that improves ore recovery, reduces dilution or shortens cycle time has economy wide implications [9].

Interviews with Orica's leadership in Peru portray an operation that services dozens of large mines with thousands of blasts per year, supported by a combination of on site teams and regional technical centres. The introduction of digital blasting platforms is a recurrent theme in these sources. International Mining reports on Orica's BlastIQ ecosystem as a digital backbone that integrates geological models, drill and blast design, field data capture and post blast measurement through tools such as FRAGTrack. This ecosystem allows engineers in Peru to design blasts with specific energy distribution profiles, simulate expected fragmentation and monitor actual outcomes [7]. Deviations from the plan, whether due to geological variability or execution issues, can be analyzed rapidly and used to refine subsequent blasts.

These practices resonate with the academic literature on numerical modelling and optimization of blasting. [4] demonstrate that soft computing approaches can incorporate multiple interacting parameters, such as burden, spacing, powder factor and rock strength, into predictive models that support continuous improvement in fragmentation outcomes. [5] show how finite element modelling of blast induced fractures can help identify optimal charge placement patterns that reduce oversize blocks and improve uniformity. t In Peru, Orica's digital tools appear to operationalize these concepts by embedding analytical capabilities into routine blast design and execution, transforming empirical knowledge into codified and shareable know how.

Innovation is not limited to software. Orica's four dimensional bulk explosives technology, described in public materials on its Latin American operations, involves the ability to vary energy and density along the column of each blasthole in real time. This capability responds to heterogeneous geology in open pits, where varying rock hardness and structural conditions can otherwise lead to inconsistent fragmentation and unwanted damage. By pairing digitally controlled delivery equipment with advanced emulsions, Orica can tune blast energy to the specific conditions of each section of the bench. Field experiences in Peru reported in industry outlets suggest that this approach has reduced the occurrence of toe problems, improved shovel productivity and lowered the amount of explosives required per cubic metre of rock, although precise quantitative results remain confidential at the mine level.

Together, these innovations shift the role of explosives and blasting from a fixed operating cost toward a strategic lever for productivity. When fragmentation is optimized, downstream processes like loading, hauling, crushing and grinding become more energy efficient, maintenance demands decrease and throughput becomes more stable. The literature on Mining four point zero highlights these system effects, arguing that digital integration across the value chain amplifies the impact of improvements in upstream activities. In Peru's case, where industry including construction already accounts for more than twenty three per cent of gross domestic product, better performance in mining can reinforce industrial growth through supplier linkages, infrastructure investment and fiscal revenues.

B. Safety and risk management as foundations for operational excellence

Safety performance is a core pillar of Orica's strategy and an area where risk management frameworks developed in academic and practitioner communities converge. Orica's recent climate and sustainability disclosures emphasize a company wide focus on fatality elimination, critical control management and high potential incident prevention, supported by training, behavioral programs and digital tools. Although safety data for Peru is generally aggregated within regional or global figures, the company's materials consistently refer to Latin America as a priority region for safety innovation, including remote operations, automation and more controlled blasting.

The academic literature helps interpret these efforts. [2] analyze decades of mining accident reports and conclude that safety culture, understood as shared beliefs, attitudes and norms regarding risk, plays a decisive role in accident causation and prevention. They highlight that technical failures often mask deeper cultural issues, such as normalization of deviance or weak reporting cultures. For a supplier like Orica, safety culture must be managed at two levels. Internally, its own employees and contractors need robust procedures, competence and leadership. Externally, Orica's practices must align with the safety cultures of client mines, which may vary widely. Digital blasting technologies contribute by reducing the need for personnel to be physically present near loaded holes and by providing traceable data on every stage of the blast, which can strengthen accountability and learning when incidents or near misses occur.

ISO 31000 provides a complementary lens. Lizarzaburu and colleagues' recent review of ISO 31000 implementation across Latin America emphasizes that risk management becomes effective only when it is embedded into everyday decisions rather than treated as a stand alone compliance exercise. In parallel, their work on governance and mining companies in Peru shows that firms with stronger governance practices achieve better stock market performance, suggesting that markets reward coherent risk and governance approaches. When Orica structures its blasting services, safety protocols and contractual arrangements in line with ISO 31000 principles and good governance expectations, it is not only responding to internal values but also aligning with the risk cultures and expectations of Peruvian mining clients and capital markets [6].

Risk management literature in Spanish speaking Latin America reinforces this message. Studies on enterprise risk management, many of which draw on ISO 31000, highlight the importance of continuous risk identification, evaluation, treatment and communication in contexts characterized by regulatory volatility and social conflict. The Peruvian mining sector has experienced social protests, community tensions and

environmental controversies that make systematic risk management indispensable. In such an environment, a blasting provider that offers not only reliable products but also structured risk analysis, modelling of blast impacts, noise and vibration control and transparent incident reporting can become a strategic ally for mining companies facing complex stakeholder landscapes.

C. *Sustainable growth, emissions reduction and green blasting*

The third dimension of the case relates to sustainable growth and climate commitments. Orica's Climate Action Report for 2024 documents progress toward a forty five per cent reduction in net scope one and two greenhouse gas emissions by twenty thirty relative to a twenty nineteen baseline. The company reports that by fiscal year 2024 it had already achieved a reduction of around twenty six per cent, primarily through process optimization, energy efficiency and the use of lower carbon feedstocks in its manufacturing facilities [8]. The ESG data pack provides further detail on absolute emissions, emission intensity per tonne of ammonium nitrate and the distribution of emissions across regions, although the data are not disaggregated to country level.

These company level efforts must be interpreted against a backdrop of global and national decarbonization pressures. Analyses of green mining technologies point to explosives and blasting as levers for reducing energy use and emissions across the mining value chain. [1] argue that improved fragmentation can reduce energy demand in comminution, one of the most energy intensive stages of mineral processing, while low emission explosives and more precise blasting can decrease fugitive emissions and mitigate impacts on water and soil quality. In Peru, where mining exports reached nearly forty eight billion United States dollars in 2024 and remain a cornerstone of the external accounts, aligning such a large sector with national and international climate commitments is critical.

Orica's innovations in Peru sit at the intersection of these agendas. Wireless initiation systems reduce the amount of reactive material required in surface detonators and lower the risk of misfires and blast failures that might otherwise lead to rework and additional emissions. Four dimensional bulk systems adjust energy precisely to rock conditions, which can avoid over blasting and unnecessary consumption of explosives. Digital platforms generate data that allow mines to quantify blast performance, correlate fragmentation with mill throughput and energy use, and calibrate future designs to emphasize both productivity and energy efficiency. In combination, these technologies offer pathways for Peruvian mines to pursue absolute or intensity based emission reductions while maintaining or improving output.

To make these relationships more concrete, Table 1 presents a synthesis of key macroeconomic and corporate indicators relevant for the Orica Peru case.

TABLE 1
SELECTED INDICATORS ON MINING DEPENDENCE AND ORICA'S EMISSIONS TRAJECTORY

Indicator	Value	Year	Source
Share of mining in Peru's gross domestic product	Approximately eight and a half per cent of GDP	Recent estimate for mid 2020	EY Peru Mining and Metals Investment Guide based on national data
Share of mineral exports in Peru's total exports	Approximately sixty three point nine per cent of total exports	2024	Corporate and analyst summaries referencing EY data for Peru
Value of Peruvian mining exports	About forty seven point seven to forty seven point nine billion United States dollars	2024	Central Reserve Bank of Peru and related trade reports
Net scope one and two greenhouse gas emissions reduction by Orica versus twenty nineteen baseline	Around twenty six per cent reduction	Fiscal year 2024	Orica Climate Action Report and ESG data pack
Targeted reduction in net scope one and two emissions by Orica	Forty five per cent reduction versus twenty nineteen	Twenty thirty target	Orica Climate Action Report and climate strategy disclosures

The table can be translated into a simple figure where the horizontal axis shows the selected indicators and the vertical axis shows values expressed as percentages or billions of United States dollars. A clustered column chart can display three bars for mining's share of gross domestic product, mineral exports' share of total exports and Orica's twenty six per cent emission reduction achieved by 2024, together with a marker or secondary bar indicating the forty five per cent reduction target for twenty thirty. The data for the first two bars would be sourced from World Bank and EY based mining investment guides for Peru, while the emissions data would be taken from Orica's Climate Action Report and ESG data pack [8], [9].

Such a figure would visually emphasize that Orica's decarbonization trajectory is already numerically comparable to macroeconomic shares that policymakers monitor closely. It also suggests that as Peru seeks to consolidate its position as a leading copper and silver exporter in an increasingly climate conscious world, the practices of key suppliers like Orica can support both competitiveness and compliance with global expectations on emissions and responsible production.

D. *Integrating innovation, safety and sustainability into Peru's industrial development*

Bringing the three dimensions together, the case study supports a more holistic view of how Orica contributes to industrial development in Peru. Technological innovation in blasting translates into higher productivity and more predictable operations at the mine level, which underpins export volumes and associated fiscal revenues. Advanced risk management and safety culture practices reduce the likelihood and severity of accidents, which not only protect workers but also avoid costly shutdowns, reputational damage and regulatory sanctions.

Sustainable growth strategies, particularly decarbonization of explosives manufacture and use, position both Orica and its clients within emerging low carbon value chains for copper and other metals.

From a governance perspective, the alignment between Orica's practices and the good governance principles documented by Lizarzaburu and colleagues in the Peruvian mining sector is especially relevant [6]. The evidence that better governed mining companies enjoy superior risk adjusted returns suggests that investors may indirectly reward suppliers whose technologies and processes contribute to safer, more transparent and more efficient operations. In Peru, where the mining sector is closely watched by communities, regulators and international markets, these attributes can be decisive for project approvals, social license and long term investment.

At the same time, the literature on risk management and ISO 31000 indicates that technological innovation cannot substitute for structured risk processes. Orica's long standing work in embedding risk management into its culture and operations aligns with the recommendations emerging from Latin American case studies, where integrating risk identification, evaluation and treatment into day to day decisions is critical for resilience. The Peruvian context, with political volatility and social pressures, reinforces the importance of such integration.

Overall, the findings suggest that Orica's role in Peru extends beyond the provision of explosives and blasting services. Through the deployment of digital platforms, advanced explosives technologies, rigorous safety and risk management frameworks and explicit climate commitments, the company supports a broader agenda of industrial development that combines productivity, risk reduction and alignment with sustainable development trajectories.

V. Conclusions

The case of Orica in Peru illustrates how a specialized supplier can influence the trajectory of a resource dependent economy by reimagining the boundaries of its own value proposition. Instead of treating explosives and blasting as a routine operational function focused solely on cost per tonne of rock broken, the company positions blasting as a strategic interface between geology, engineering, safety and sustainability. This repositioning has practical consequences for industrial development.

First, the analysis shows that technological innovation in blasting can amplify the contribution of mining to Peru's gross domestic product and export earnings by improving productivity and reliability at the mine level. Digital platforms, numerical modelling and advanced bulk systems enable more precise control over fragmentation and energy distribution, which in turn improves the performance of loading, hauling and processing circuits. In a country where minerals account for a high share of exports and an important portion of gross domestic product, these gains resonate through the broader economy via supplier linkages, infrastructure demand and public revenues.

Second, the case underlines that innovation cannot be decoupled from safety and risk management. The most sophisticated blasting technology would be unsustainable if it did not coexist with robust safety culture, structured risk management frameworks and governance arrangements that foster transparency and accountability. Orica's emphasis on fatality elimination, critical control management and alignment with ISO 31000 principles echoes the recommendations of academic work on safety culture and enterprise risk management, including Latin American contributions led by Lizarzaburu and other scholars[6]. By investing in people, processes and digital tools that strengthen safety and risk oversight, the company contributes to the resilience of Peruvian mining operations and, indirectly, to the stability of national output and exports.

Third, the findings point to a growing alignment between Orica's decarbonization trajectory and the global expectations facing Peru as a major copper and silver exporter. The reported reduction in net scope one and two emissions since twenty nineteen and the ambitious target for twenty thirty suggest that explosives manufacture and use can be meaningfully decarbonized without undermining operational performance. When combined with innovations that improve fragmentation and reduce energy use in downstream processes, these actions position Peruvian mining operations to participate credibly in low carbon supply chains and to respond to the climate related criteria increasingly used by investors, buyers and regulators.

A broader lesson emerging from the case is that industrial development in a mining intensive economy is not determined solely by the volume of ore extracted or the prices achieved on global markets. It also depends on the quality of the technologies deployed, the sophistication of risk management and governance, and the capacity to align operational practices with long term sustainability objectives. Suppliers such as Orica can therefore be seen as partners in development rather than mere vendors. Their choices regarding research and development investment, safety programs and climate strategies have direct implications for the competitiveness and legitimacy of mining in Peru.

Future research could deepen this analysis by incorporating primary data from Peruvian mine sites, including quantitative measures of productivity improvements, safety outcomes and emissions reductions linked specifically to digital blasting and advanced explosives. Comparative studies between operations that have adopted these technologies and those that continue to rely on more traditional approaches would help quantify the incremental benefits identified qualitatively in this paper. It would also be valuable to explore how community perceptions of blasting evolve when suppliers and mining companies can demonstrate concrete reductions in vibration, noise and dust, supported by transparent data and participatory monitoring.

In sum, the Orica Peru case supports a more integrated understanding of industrial development in mineral economies.

By bringing together innovation, safety and sustainable growth within a coherent risk management and governance framework, the company contributes to a version of mining that is not only more productive but also more responsible and resilient. For policymakers, investors and communities, recognizing and leveraging this type of supplier contribution may be an important step in aligning extractive activities with long term national development goals in Peru and comparable contexts.

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