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LINKING QUALITY MANAGEMENT TO COMPANY PERFORMANCE THROUGH INNOVATION: A SEM APPROACH IN THE CROATIAN METAL SECTOR

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Abstract

Quality management demands standardization. Innovation demands experimentation. How manufacturing firms reconcile the two is not settled in the empirical literature. This paper tests the relationship between quality management practices, innovation types, and company performance using survey data from 200 Croatian metal processing firms. Partial Least Squares Structural Equation Modelling is applied to the pathways connecting quality management with product, process, and business model innovation and their respective links to performance. The results indicate that quality management predicts all three innovation types, with the strongest association being with process innovation ($\beta = 0.571$). The innovation–performance pathways diverge. Process innovation is the dominant performance driver ($\beta = 0.444$). Business model innovation contributes moderately ($\beta = 0.264$). Product innovation shows no significant direct link ($\beta = 0.008$). In commodity-oriented manufacturing, product novelty is not automatically rewarded in market results.

Keywords: quality management, product innovation, process innovation, business model innovation, company performance, PLS-SEM, metal processing industry.

JEL Classification: L15, O31, O32, L61.

1. Introduction

Quality management and innovation pull in opposite directions. Quality management requires standardization, repeatability, and variance reduction. Innovation requires experimentation and departure from established routines. Manufacturing firms have to do both at once. Predictable output must be delivered to existing customers while products, processes, and business models are renewed to remain competitive (Escrig-Tena, Garcia-Juan, and Segarra-Ciprés 2019; Zeng, Phan, and Matsui 2015; García-Fernández, Claver-Cortés, and Tarí 2022).

The empirical record on how the two interact is mixed. Research generally reports that quality management practices support innovation activity (Zeng, Phan, and Matsui 2015; Chen et al. 2017; El Manzani, Sidmou, and Cegarra 2019; Mushtaq and Peng 2020). However, several authors argue that excessive focus on standardization may restrict creative behaviour (Palm, Lilja, and Wiklund 2016; Hannan and Freeman 1984; Escrig-Tena, Segarra-Ciprés, and García-Juan 2021). A specific research gap remains. The simultaneous effects of quality management and multiple innovation types on firm performance in export-oriented manufacturing have not been tested in an integrated model. This paper addresses that gap.

Three specific contributions are made. Innovation is disaggregated into product, process, and business model innovation. Each type is examined as a separate mediating channel between quality management and performance. Earlier work typically treated innovation as a single aggregate concept (Kafetzopoulos, Gotzamani, and Gkana 2015; Kaynak 2003). The three pathways carry distinct implications for firm results. The empirical setting is also non-standard: a mature, export-oriented manufacturing sector in a small transition economy. Such settings are underrepresented in the mainstream innovation literature, which focuses on Western and high-technology contexts (Mahmutaj and Krasniqi 2020). PLS-SEM is applied to 200 Croatian metal processing firms. The quality–innovation–performance system is tested in a single integrated model.

The Croatian metal processing sector provides a useful empirical anchor. According to the Croatian Chamber of Commerce (2023), the sector employs more than 82,000 workers and generates EUR 7.85 billion in revenue. Exports account for 56.45% of that revenue. Strong export exposure means that domestic firms face cost discipline and reliability requirements set by larger international competitors. Digital technologies are reshaping competitive conditions across the global metals industry. Early adopters of automation, robotics, additive manufacturing, and data-driven process control in steel and metals report sizeable gains in equipment uptime, energy efficiency, and throughput (Frank, Dalenogare, and Ayala 2019; Ghobakhloo 2018; Bag, Gupta, and Kumar 2021). Process-level innovation has growing relevance in sectors traditionally regarded as mature.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 develops the hypotheses. Section 4 describes the data and methods. Section 5 reports the results. Section 6 discusses the implications. Section 7 concludes.

2. Literature review

Scholarly work on quality management, innovation, and performance has grown substantially over the past two decades. A systematic review of 172 studies by García-Fernández, Claver-Cortés, and Tarí (2022) concluded that quality management practices are positively associated with both product and process innovation (incremental and radical) and with operational and financial results, through direct and indirect pathways. However, most empirical contributions still treat the three constructs in isolation rather than within an integrated framework. Early research established quality management as a significant antecedent of organizational performance (Baković 2011; Kaynak 2003). ISO 9001 certification was frequently used as a proxy for systematic quality practice.

Kafetzopoulos, Gotzamani, and Gkana (2015) argued that the quality–performance link is not purely direct but is mediated, at least in part, by innovation capabilities. This mediation logic provides the conceptual backbone of the model tested here.

Many contributions have examined the mechanisms through which quality management supports innovation. Zu, Robbins, and Fredendall (2010) showed that an organizational culture grounded in quality management enables both exploitative and exploratory learning. Prajogo and McDermott (2005) demonstrated that distinct cultural profiles (group, developmental, rational) moderate the quality–innovation relationship in different ways. Sciarelli, Gheith, and Tani (2020) reported that soft quality management practices exert a stronger effect on innovation performance than hard statistical controls, with organizational performance as the final outcome. Mushtaq and Peng (2020) reached a similar conclusion in Pakistani manufacturing, where both soft and hard TQM dimensions triggered innovation performance via business innovation capability. In manufacturing, these cultural and managerial foundations translate into observable outcomes. Firms with embedded quality management routines engage more systematically in process improvement, product development, and strategic renewal (Zeng et al. 2017; El Manzani, Sidmou, and Cegarra 2019).

Innovation dynamics in mature manufacturing sectors such as metal processing differ from those typical of high-technology industries. Buyers specify standardized materials, dimensions, and tolerances. The room for product differentiation is therefore structurally narrow. Reliable conformance to specification, on time and at competitive cost, is what matters under these conditions. Process innovation becomes the main competitive lever. Firms that manufacture standard outputs faster, with fewer defects, and at lower energy and material cost gain a tangible market advantage (Gunday et al. 2011; Utterback and Abernathy 1975). Business model innovation offers a complementary path. Supply chains can be reconfigured, products can be bundled with services, and new customer segments can be entered without reliance on product novelty (Teece 2010; Casadesus-Masanell and Ricart 2010; Clauss et al. 2021).

Evidence from transition economies in South East Europe is directly relevant to the research setting. Mahmutaj and Krasniqi (2020) found that different innovation types exert differential effects on sales growth among small firms in Kosovo. This result complicates the assumption of a uniform innovation–performance relationship. Vujanović (2021) documented upward technological trends across manufacturing sectors in Montenegro between 2010 and 2019. Even traditional industries in small economies can advance technologically when supported by appropriate management frameworks. Turulja et al. (2023) showed that innovation mediates the link between human resource management practices and organizational performance in Bosnia and Herzegovina. Pilav-Velić et al. (2021) traced how digital literacy and innovative work behaviour generate chains of value creation. This regional stream of evidence indicates that well-structured management practices, including quality management, support innovation activity even where institutional and resource constraints could otherwise restrict it.

A further reason to expect process-led innovation gains in the metals sector lies in the Industry 4.0 transition. Real-time sensor networks, predictive maintenance algorithms, and automated quality inspection are gradually becoming standard in leading steel and metals plants. Documented gains include improved equipment effectiveness, reduced downtime, and lower energy consumption (Ghobakhloo 2018; Frank, Dalenogare, and Ayala 2019; Bag, Gupta, and Kumar 2021). Survey evidence on Croatian manufacturing more broadly indicates that adoption of advanced digital technologies remains uneven and concentrated among larger firms (Croatian Chamber of Commerce 2023). Quality management systems, when paired with digital capabilities, can serve as platforms for accelerated process innovation. The empirical findings reported in Section 5 support this argument.

3. Hypothesis development

3.1. Quality management as a predictor of innovation

Two competing theoretical lenses inform this relationship. The innovation-enhancing view, rooted in dynamic capabilities theory and the resource-based view (Teece, Pisano, and Shuen 1997; Teece 2007; Barney 1991), argues that quality management builds organizational routines that directly support innovation. A culture of continuous improvement normalizes change (Prajogo and Sohal 2006). Systematic data collection reveals concrete improvement opportunities (Zeng et al. 2017). Customer orientation ensures that innovation is pulled by market needs rather than pushed by technology (Santos-Vijande and Álvarez-González 2007). Cross-functional collaboration loosens departmental silos that often obstruct innovative projects (Molina, Lloréns-Montes, and Ruiz-Moreno 2007). Bezdrob and Šunje (2014) demonstrated in the South East European context that structured management practices build capabilities for innovation diffusion across organizational levels.

The innovation-constraining view, by contrast, warns that insistence on control and variance reduction may generate organizational rigidity (Palm, Lilja, and Wiklund 2016; Hannan and Freeman 1984). The empirical work has largely resolved this tension by distinguishing implementation style. Soft quality practices, such as leadership commitment, employee empowerment, and continuous learning, tend to enhance innovation. Exclusive focus on hard statistical controls can inhibit it (Zeng et al. 2017; Zeng, Phan, and Matsui 2015; Perdomo-Ortiz, González-Benito, and Galende 2006; Sciarelli, Gheith, and Tani 2020). Singh, Darwish, and Potočnik (2016) argue that quality management reinvigorates product, process, and administrative innovation when aligned with internal organizational contingencies.

Product innovation refers to the introduction of goods or services that are new or substantially improved in technical specifications, components, or functional characteristics (OECD 2018). Quality management supports product innovation through Voice of Customer processes that capture latent needs. Cross-functional project structures integrate design, engineering, and marketing expertise. Robust design principles secure manufacturability from the outset (Flynn, Schroeder, and Sakakibara 1994; García-Morales, Jiménez-Barrionuevo, and Gutiérrez-Gutiérrez 2012; Kaynak 2003). El Manzani, Sidmou, and Cegarra (2019) provide evidence that ISO 9001-based quality systems contribute positively to product innovation outcomes. Escrig-Tena, Segarra-Ciprés, and García-Juan (2021) further show that quality management supports incremental product innovation more consistently than radical product innovation.

H1: Quality management has a positive impact on product innovation.

Process innovation involves the adoption of new or significantly improved production or delivery methods (OECD 2018). Quality management and process innovation share a common methodological grammar. Both rely on systematic problem-solving, measurement, and iterative refinement. The Plan-Do-Check-Act cycle, statistical process control, and lean principles originate within quality management thinking. In practice they operate as engines of process innovation (Prajogo and Sohal 2006; Molina, Lloréns-Montes, and Ruiz-Moreno 2007). Empirical evidence reports a robust positive link between quality management and process-level innovation (Zeng et al. 2017; Kafetzopoulos, Gotzamani, and Gkana 2015).

H2: Quality management has a positive impact on process innovation.

Business model innovation involves changes in how an organization creates, delivers, and captures value (Teece 2010; Clauss et al. 2021). Quality management contributes to this form of innovation. Deep customer insight is generated. Stakeholder relationship management capabilities are built. Process management competencies needed to reconfigure value chains are developed (García-Morales, Jiménez-Barrionuevo, and Gutiérrez-Gutiérrez 2012; Santos-Vijande and Álvarez-González 2007). Salfore, Ensermu, and Kinde (2023) reported that changes in any business model component (value creation, value proposition, or value capture) are positively associated with manufacturing SME performance.

H3: Quality management has a positive impact on business model innovation.

3.2. Innovation types as predictors of company performance

The resource-based view holds that innovation produces unique, hard-to-imitate resources that underpin sustained competitive advantage (Barney 1991). Dynamic capabilities theory frames innovation as a vehicle for organizational adaptation (Teece, Pisano, and Shuen 1997; Teece 2007). Evidence from transition economies supports these arguments. Turulja et al. (2023) reported that innovation significantly mediates the link between management practices and performance. Well-structured management approaches translate into performance gains primarily through their innovation effects.

Product innovation creates distinctive value propositions and enables firms to respond to shifting customer preferences (Schumpeter 1942; Christensen 1997). Srivastava, Franklin, and Martinette (2013) report a positive association between innovation strategy and competitiveness. Ramadani et al. (2019) find positive product innovation–performance effects in transition economies.

H4: Product innovation has a positive impact on company performance.

Process innovation drives performance mainly through operational gains. Production costs are lowered. Throughput is raised. Cycle times are shortened. Defect rates fall (Utterback and Abernathy 1975; Davenport 1993). Manufacturing firms in emerging economies that compete on cost against larger international rivals depend heavily on such operational gains (Zhou and Wu 2010; Bag, Gupta, and Kumar 2021).

H5: Process innovation has a positive impact on company performance.

Business model innovation opens new value sources and establishes competitive positions whose systemic nature makes them difficult to replicate (Teece 2010; Casadesus-Masanell and Ricart 2010). Clauss et al. (2021) demonstrated in a sample of 432 German firms that strategic agility translates into firm performance primarily through business model innovation, particularly under conditions of environmental turbulence. Pilav-Velić et al. (2021) illustrated how digital literacy and innovative work behaviour generate value-creation chains that extend beyond traditional operational improvements.

H6: Business model innovation has a positive impact on company performance.

4. Methodology

4.1. Research design and sample

Data were collected through a structured online questionnaire. The instrument was distributed to companies classified under Croatia's metal processing sub-sectors according to the National Classification of Economic Activities (NKD 2007). The target population comprised approximately 6,000 registered firms. The sector covers primary metal manufacturing, fabricated metal products, machinery production, and metalworking services. A database obtained from the Croatian Chamber of Commerce was used for email distribution. Two reminder waves were sent at fortnightly intervals.

A total of 200 usable responses were obtained. The response rate was approximately 3.3%. Although modest, this rate falls within the range reported in survey studies targeting manufacturing firms. The sample size is adequate for structural equation models of moderate complexity (Hair et al. 2019). Sample composition by firm size was as follows: 84 small firms with fewer than 50 employees (42%), 74 medium-sized firms with 51 to 250 employees (37%), and 42 large firms with more than 250 employees (21%). Geographic distribution followed the pattern of Croatian industrial concentration. The largest cluster of respondents was located in Zagreb and its surroundings (34%). The continental region accounted for 29%, the Adriatic coast for 22%, and eastern Croatia for 15%. Among respondents, 136 firms (68%) held ISO 9001:2015 certification. This proportion is above the national manufacturing average.

Non-response bias was assessed by comparing the first quartile of respondents (early replies) with the last quartile (late replies). Independent-samples t-tests were used on firm size, export orientation, and certification status. No statistically significant differences were found ($p > 0.05$ in all cases). The likelihood that non-response bias materially affects the results is therefore low.

4.2. Measurement instruments

All constructs were operationalized using established scales. Unless noted otherwise, items were measured on a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree).

Quality management was captured with Kaynak's (2003) multidimensional instrument. The scale includes four facets: data quality and reporting (4 items), supplier relations (3 items), product/service design (4 items), and process management (4 items). Representative items include "Quality data are available to managers and employees" and "We work closely with suppliers to improve each other's processes."

Product innovation was assessed with the Alegre, Lapiedra, and Chiva (2006) scale. Respondents rated their firm's innovation performance relative to competitors (1 = much worse, 7 = much better) across four items. Item content covers technical novelty, use of new materials, and market responsiveness.

Process innovation was measured using the Gunday et al. (2011) five-item scale. Benchmarking against competitors was again applied. Items address logistics cost reduction, waste elimination, and adoption of new production technologies.

Business model innovation was operationalized with the Snihur and Wiklund (2019) seven-item scale. Item content covers novelty in partnerships, revenue models, and value delivery mechanisms.

Company performance was measured with the Gunday et al. (2011) multi-item scale. Financial and operational indicators are captured, including market share growth, profitability, and customer satisfaction, assessed relative to competitors.

4.3. Analytical approach

The model was estimated using Partial Least Squares SEM (PLS-SEM) in SmartPLS 4.0. Quality management was specified as a second-order reflective construct composed of its four dimensions. Product, process, and business model innovation, together with company performance, were modelled as first-order reflective constructs. PLS-SEM was selected for three reasons. The model includes a second-order construct. The research goal is partly exploratory (multiple innovation types examined simultaneously). The sample size, although adequate, favours a variance-based approach (Hair et al. 2019; Crossan and Apaydin 2010; Foss and Saebi 2017).

5. Results

5.1. Measurement model

Table 1 reports the reliability and validity statistics. Internal consistency was satisfactory across all constructs. Cronbach's alpha values range between 0.811 and 0.924. Composite reliability coefficients range between 0.877 and 0.938. Both sets are above the conventional 0.70 threshold. Average variance extracted (AVE) ranges from 0.576 to 0.748, exceeding the 0.50 benchmark for convergent validity.

Table 1. Construct reliability and validity

Construct	Cronbach's α	CR	AVE	Items
Quality management	0.924	0.938	0.748	15
Product innovation	0.865	0.906	0.708	4
Process innovation	0.847	0.895	0.682	5
Business model innovation	0.823	0.877	0.576	7
Company performance	0.811	0.889	0.615	5

Note. CR = Composite Reliability; AVE = Average Variance Extracted. Thresholds applied: α and CR ≥ 0.70; AVE ≥ 0.50 (Hair et al. 2019). Source: authors' calculation.

Model fit statistics indicate acceptable fit. The SRMR of 0.078 falls below the 0.08 threshold commonly applied in PLS-SEM. The NFI of 0.732 sits below the conventional 0.90 cut-off. However, NFI tends to underperform in composite-based models and should be interpreted with caution (Hair et al. 2019). The chi-square statistic (χ^2 = 1,311.70) is reported for completeness. Its inferential value in PLS-SEM is limited by sensitivity to sample size and model complexity.

5.2. Structural model and hypothesis testing

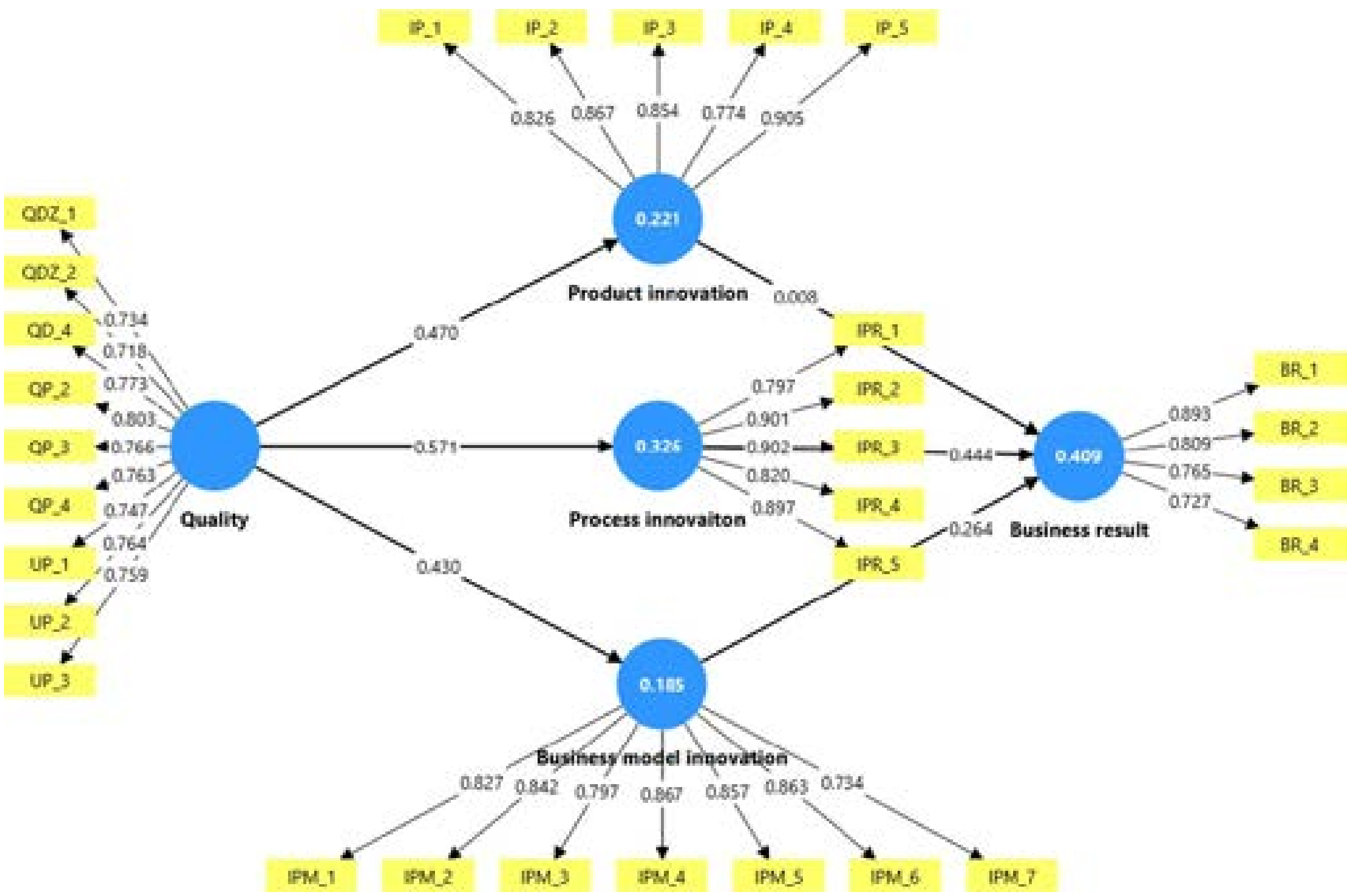
Table 2 displays the path coefficients and significance levels for all hypothesized relationships. The contribution of single variables and measurement instruments is also shown in Figure 1. Quality management exerted positive and significant effects on every innovation type. The strongest path connects quality management to process innovation (β = 0.571, $p < 0.001$). Next comes product innovation (β = 0.470, $p < 0.001$), followed by business model innovation (β = 0.430, $p < 0.001$). Hypotheses 1, 2, and 3 are confirmed.

Table 2. Hypothesis testing results

Relationship	β	**p-value**	**Result**
QM → Product innovation (H1)	0.470	< 0.001	Supported
QM → Process innovation (H2)	0.571	< 0.001	Supported
QM → Business model innovation (H3)	0.430	< 0.001	Supported
Product innovation → Performance (H4)	0.008	> 0.10	Rejected
Process innovation → Performance (H5)	0.444	< 0.001	Supported
Business model innovation → Performance (H6)	0.264	< 0.05	Supported

Note. QM = quality management. β = standardized path coefficient. n = 200. Estimation via PLS-SEM with 5,000 bootstrap resamples (SmartPLS 4.0). Source: authors' calculation.

Figure 1. Structural model with standardized path coefficients



Note. Coefficients shown are standardized β values. Solid arrows indicate statistically significant paths ($p < 0.05$). Source: authors' estimation in SmartPLS 4.0.

The figure presents a PLS-SEM structural model in which Quality is the main independent construct on the left side of the diagram. Quality is measured by several observed indicators shown as yellow rectangles, including quality-related items such as QD, QP, and LP indicators. From Quality, three arrows lead to three innovation constructs in the middle of the figure: Product innovation, Process innovation, and Business model innovation. The standardized path coefficient from Quality to Product innovation is 0.470. Product innovation has an explained variance of R^2 = 0.221 and is measured by five indicators labelled P_1 to P_5. The path from Product innovation to Business result is very small, with a coefficient of 0.008, indicating no meaningful direct association in the model. The standardized path coefficient from Quality to Process innovation is 0.571, the strongest path from Quality to the innovation constructs. Process innovation has an explained variance of R^2 = 0.326 and is measured by five indicators labelled PR_1 to PR_5. The path from Process innovation to Business result is 0.444, making it the strongest direct predictor of business results in the model. The standardized path coefficient from Quality to Business model innovation is 0.430. Business model innovation has an explained variance of R^2 = 0.185 and is measured by seven indicators labelled PM_1 to PM_7. The path from Business model innovation to Business result is 0.264, indicating a moderate positive relationship. The final dependent construct, Business result, is shown on the right side of the model. It has an explained variance of R^2 = 0.409 and is measured by four indicators labelled BR_1 to BR_4. Overall, the model indicates that quality management positively predicts all three innovation types, while business results are mainly explained by process innovation and, to a lesser extent, business model innovation. Product innovation has almost no direct effect on business results in this model.

The innovation–performance pathways yielded markedly different results. Process innovation emerged as the dominant contributor to performance (β = 0.444, $p < 0.001$), confirming Hypothesis 5. Business model innovation showed a moderate but significant positive effect (β = 0.264, $p < 0.05$), confirming Hypothesis 6. Product innovation had virtually no direct relationship with performance (β = 0.008, $p > 0.10$). Hypothesis 4 is rejected.

6. Discussion

6.1. Principal findings

Empirical evidence generally places process innovation as the most responsive innovation type in mature manufacturing (Gunday et al. 2011; Utterback and Abernathy 1975). Zeng et al. (2017) reported a positive link between quality management practices and process-level innovation across industry contexts. The present results are consistent with that body of work. The strongest quality management pathway in this study leads to process innovation (β = 0.571). Process innovation is also the dominant predictor of performance (β = 0.444). In the Croatian metal processing sector, where firms manufacture largely standardized products for price-sensitive and specification-driven customers, this pattern is consistent with industry logic. Operational improvements translate into improved margins. Practitioners in the sector should treat process innovation as the primary channel for quality-driven performance gains.

The literature on product innovation in commodity-oriented industries is less uniform. Mahmutaj and Krasniqi (2020) reported differential innovation effects among small firms in Kosovo, where product innovation did not consistently drive sales growth. Ramadani et al. (2019) found positive product innovation–performance effects in transition economies but in sectors with greater product differentiation potential. Escrig-Tena, Segarra-Ciprés, and García-Juan (2021) document that quality management environments favour incremental product innovation, whose market payoff is typically less visible in short observation windows. The present analysis observed no significant direct effect of product innovation on performance (β = 0.008). The result is context-specific rather than anomalous. In a commodity-oriented industry, customers specify materials, grades, and tolerances. The room for differentiation through product novelty is structurally narrow. Product innovation may still carry value as a defensive function (maintaining qualification on customer tender lists) or through indirect channels (reputation effects, entry into adjacent segments) that unfold over horizons longer than a cross-sectional design can capture. There is a need to interpret product innovation results from this sector in relation to its standardization constraints rather than in relation to general innovation theory.

The business model innovation literature positions this innovation type as a route to differentiation that does not rely on product novelty (Teece 2010; Casadesus-Masanell and Ricart 2010; Clauss et al. 2021). Pilav-Velić et al. (2021) documented how digital literacy and innovative work behaviour generate value-creation chains beyond operational improvements. The present results align with that positioning. Business model innovation showed a moderate but significant effect on performance (β = 0.264, $p < 0.05$). Some firms in the sample appear to have used the quality management infrastructure to reconfigure their value delivery. Examples observed in the data include a shift from spot sales of standard products to longer-term integrated supply agreements, and the bundling of basic metal products with logistics, cutting, and surface treatment services. Business model innovation represents a meaningful source of performance differentiation in this sector. Managers should treat it as a complement to process innovation rather than a substitute.

6.2. Theoretical contributions

Three specific contributions to the literature follow from these results. Strong empirical support is provided for the innovation-enhancing view of quality management. The earlier work of Baković, Lazibat, and Sutić (2013) identified quality systems as platforms for innovation diffusion. The present data extend that view. The enabling role observed here applies across all three innovation types, not only to incremental process improvement.

Disaggregation of innovation into product, process, and business model dimensions shows that treating innovation as a monolithic construct obscures critical variation. The product innovation–performance non-result in particular would have been invisible in a model that collapsed all innovation into a single latent variable. The methodological lesson for future research is direct. The choice of innovation operationalization matters substantively, not just technically.

A clarification on ISO 9001 certification is required. The quality management construct used here draws on the Kaynak (2003) instrument. It measures the degree of practice adoption (data quality, supplier relations, product/service design, process management) rather than certification status as such. Performance gains observed in the analysis should be attributed to those underlying practices, not to ISO certification. Companies with ISO 9001 should be separated into a new sample and compared to the rest. ISO 14001 (environmental management), ISO 45001 (occupational health and safety), and customer-specific industrial standards are also in use. Disentangling the differential effects of various other certifications is a productive direction for future work.

The study adds to the growing evidence from South East European transition economies. It complements the work of Vujanović (2021) on technological trends in Montenegrin manufacturing, Bezdrob and Šunje (2014) on management innovation in Bosnia and Herzegovina, and Turulja et al. (2023) on the mediating role of innovation between HRM and performance. Read together, this regional research shows that quality management infrastructures, often developed around ISO certification, can serve as functional platforms for innovation activity even where resource and institutional constraints are present.

6.3. Practical implications

The analysis points to a direct implication for managers in metal processing and similar mature manufacturing sectors. Quality management should be approached as an investment in innovation capability, not as a cost of compliance. The strong quality–innovation links documented here indicate that firms cultivating quality cultures (continuous improvement, employee engagement, data-driven problem-solving) are simultaneously building the foundations for innovation across multiple domains.

Innovation budgets in commodity-oriented industries should weight process innovation more heavily than the alternatives. The data show that returns to process innovation (β = 0.444) are substantially higher than returns to product innovation (β = 0.008) or business model innovation (β = 0.264). Resources directed toward automation, waste reduction, cycle time compression, and energy efficiency are most likely to yield tangible performance gains. Product innovation budgets can still be justified on defensive grounds (retaining customer tender qualification), but should not be expected to produce direct short-term performance improvements in this sector.

There is a need for policy makers in small transition economies to build on the existing quality management base. Programs supporting quality management adoption (training, certification subsidies, technical assistance) carry multiplier effects through their catalytic impact on innovation. Among the firms in this sample, 68% already hold ISO 9001 certification. That base provides a concrete platform for further interventions, particularly those targeting process-level digital transformation.

6.4. Limitations and future research

The cross-sectional design precludes causal inference. Longitudinal data would permit investigation of time-lag effects. Such effects are particularly relevant for product innovation, whose performance benefits may materialize over horizons that a single survey cannot capture (Ramadani et al. 2019). Replication in a panel design across two or three years is the direct next step.

The single-industry, single-country design constrains generalizability. Replication in other manufacturing sectors with different product-differentiation characteristics (food processing, automotive components) and in other transition economies would clarify how far the findings extend. The choice of metal processing was deliberate: it is the sector with the strongest export exposure and the most standardized product portfolio in Croatia. That choice also limits how directly the results apply to sectors where product novelty carries higher market weight.

The product innovation scale used here relies on perceptual self-assessment relative to competitors. This may understate the true effect of product innovation in a sector where incremental improvements are common but difficult to articulate in survey responses. Objective indicators (patent activity, frequency of new product launches, revenue share from new products) would provide a more complete picture. Their absence from the present dataset is the specific methodological trade-off accepted for the sake of response rate and comparability with Alegre, Lapiedra, and Chiva (2006).

Moderating variables were not examined. Firm size, export intensity, and the degree of digital technology adoption may all condition the pathways identified here. Industry 4.0 readiness in particular could amplify the link between quality management and process innovation (Bag, Gupta, and Kumar 2021). Future work should test these moderators and examine how specific quality management sub-dimensions (rather than the aggregate construct) differentially affect each innovation type.

7. Conclusion

This study tested how quality management, multiple innovation types, and company performance interconnect in the Croatian metal processing industry. The structural equation model confirms that quality management serves as a broad antecedent of innovation. Product, process, and business model innovation are all supported. However, the onward pathways from innovation to performance are not uniform. Process innovation stands out as the dominant performance driver. Business model innovation makes a meaningful if moderate contribution. Product innovation shows no significant direct link with firm results in this context.

Innovation is not monolithic. Its performance consequences depend on industry characteristics and on the specific innovation type under consideration. This is the central theoretical takeaway.

For practice, three concrete actions follow. Managers in mature manufacturing should treat quality management as an innovation platform rather than as a compliance tool. Innovation investment should be directed primarily toward operational efficiency and, secondarily, toward business model reconfiguration. Product innovation programs should be justified on defensive grounds where market conditions do not support direct performance returns. For policy, investment in quality management capability acts as a lever with multiplier effects on innovation, and through innovation, on competitiveness. Training programs, certification subsidies, and technical assistance directed at small and medium-sized firms in the metal processing sector are the most direct instruments available.

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