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DiProMo model: PLS-SEM validation of the link between digital transformation, business model, and productivity

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ABSTRACT

This paper validates the DiProMo model, which seeks to establish relationships among Digital Transformation (DT), the Business Model (BM), and Productivity (P), using a sequential mixed-methods approach that integrates a systematic literature review, expert interviews, and a survey of 318 professionals, whose data were analysed using PLS-SEM in SmartPLS 4. The results show that DT has a significant effect on innovation, which is part of the BM ($\beta = 0.783$), which in turn generates a positive effect on P ($\beta = 0.755$). Likewise, a direct impact of DT on P is observed ($\beta = 0.734$), and a robust partial mediation of DT with P through the BM is also evident. The overall model fit (SRMR = 0.069) and high predictive values ($Q^2 > 0.50$) support the validity and utility of the proposed model. The results indicate that P increases when digital investment is aligned with strategic design in BM, providing empirical evidence and practical guidance for organisational management and the formulation of DT policies geared towards competitiveness.

1. Introduction

Digital Transformation (DT) has emerged as one of central drivers for organisational competitiveness, reconfiguring industries, dynamic capabilities, and organisational routines [1,2]. Although empirical studies consistently examine DT's effects, evidence indicates that performance outcomes do not arise solely from technological adoption but depend on firms' capacity to redesign their Business Models (BM) to create, deliver, and capture value in new ways [3, 4]. Recent systematic reviews emphasise that the productivity (P) outcomes associated with DT remain contingent on organisational and BM redesign mechanisms [5, 6]. Despite these contributions, the literature still lacks an integrated explanatory model that clarifies how digital investments, as a key part of DT, contribute to increases in P, when mediated by innovations in the BM, which constitutes a conceptual and empirical gap addressed in this study. Building on the existing literature, this study also distinguishes among digitisation, digitalisation, and DT. Digitisation means the technical process of converting analog information into digital formats. Digitalisation is defined as the use of digital technology to improve or automate existing processes and activities. DT, on the other hand, is a more

general organisational and strategic framework that refers to a process that encompasses digitisation and digitalisation and also includes modifying BM, organisational structures, capabilities, and value-creation logics. In this paper, DT is conceptualized as a higher-order construct which is interrelated to and transcends both digitisation and digitalisation. This paper aims to validate the DiProMo model, which conceptualises and tests the causal relationships linking DT, BM, and P. The model is estimated using partial least squares structural equations modelling (PLS-SEM) in SmartPLS 4, based on a sequential mixed design that integrated a systematic literature review (SLR), semi-structured expert interviews, and a multisector survey. The DiProMo model tests four causal hypotheses: the influence of DT on innovations in BM (H1), the DT has a positive impact on P (H2), Innovation in the BM has a positive effect on P (H3), and Innovation in the BM partially mediates the effect of DT on P (H4). This paper shows empirical and predictive evidence of the DT to BM to P causal chain. It operationalizes the transfer of value from statistically validated and reflexively operationalized constructs, and it also delivers an appropriate methodology for conducting comparative applications. This study is grounded in a complementary set

of perspectives that jointly explain the relationships between DT, BM through innovation, and P. In particular, the proposed DiProMo model builds on dynamic capabilities theory to explain organisational adaptation; the resource-based view seeks to conceptualize digital assets and capabilities as sources of competitive advantage, and socio-technical systems and ecosystem perspectives seek to capture the interaction between technology, organisational structures, and external actors.

Abbreviations	
AI	Artificial Intelligence
AVE	Average Variance Extracted
BM	Business Model
CDO	Chief Data Officer
CFA	Confirmatory Factor Analysis
CIO	Chief Information Officer
CR	Composite Reliability
CTO	Chief Technology Officer
DiProMo	Digital Transformation, Business Model, and Productivity
DT	Digital Transformation
E2E	End-to-End
EFA	Exploratory Factor Analysis
FPY	First Pass Yield
GVA	Gross Value Added
HTMT	Heterotrait–Monotrait ratio
ICT	Information and Communication Technologies
IT	Information Technology
KMO	Kaiser–Meyer–Olkin measure
MFP	Multifactor productivity
P	Productivity
PLS-SEM	Partial Least Squares Structural Equation Modelling
RODA	Return on Digital Assets
RPA	Robotic Process Automation
SLR	Systematic Literature Review
SmartPLS 4	Smart Partial Least Squares, version 4
SRMR	Standardized Root Mean Square Residual
VIF	Variance Inflation Factor
Nomenclature	
α	Cronbach’s alpha
β	Beta coefficient
λ	Outer loading
Q^2	Stone–Geisser’s Q-squared
R^2	Coefficient of determination

The contribution of the study is twofold. On one hand, the DiProMo model demonstrates theoretically that digital technologies, as a component of DT, influence the BM through innovation, which affects P. On the other hand, in practice, the DiProMo model provides a framework for organisational decision-making, enabling the development of digital strategies aligned with the BM. By strengthening this alignment, companies can improve their position to convert digital investments into long-term P and competitive gains. This paper is structured as follows. The second section presents the theoretical foundations and hypotheses. The third section describes the research method. The fourth section reports the main empirical results. The fifth and sixth

sections discuss the research results and limitations. The seventh section present the conclusions.

2. Theoretical foundations and hypotheses

Dynamic capabilities theory provides the primary explanatory logic of the model, as it frames DT as an ongoing process of sensing, seizing, and reconfiguring organisational resources in response to technological change. In this context, innovation in BM represents a key reconfiguration mechanism through which digital capabilities are translated into productivity outcomes [7-9]. Further, the resource-oriented perspective views digital technologies, data and analytics as strategically valuable assets, not inherently intrinsic but conditioned on integration into the BM itself. Additionally, digital ecosystems are understood as interconnected networks of organisations, technologies, data, and actors that collaborate digitally to co-create, exchange, and capture value within organisations, thereby impacting those organisations' BM [10,11]. Socio-technical and ecosystem perspectives further elucidate how DT modifies the relationships among technology, organisational practices, and external stakeholders.

Within the literature on organisational performance, DT is conceived as a disruptive process that reconfigures strategies, structures, and capabilities, enabled by digital technologies that generate both opportunities and tensions. While digitisation and digitalisation constitute necessary enabling mechanisms, they are not sufficient conditions for DT. DT implies an intentional and coordinated reconfiguration of strategy, BM, organisational routines, and governance structures, rather than the mere deployment of digital tools [7]. The impact of DT is not produced in isolation, since its organisational effects are mainly channelled through innovation in BM, understood as systems of interdependent activities that configure the mechanisms through which value is created, delivered, and captured [12,13]. Therefore, DT supports the process that allows for the reformulation of value propositions, revenue generation mechanisms, and organisational architectures, as do the other six components presented by Osterwalder in Ref. [4], thus strengthening sustainability and competitive differentiation [10,11]. This section shows the theoretical elements of the causal relationships examined in the paper based on the SLR findings.

2.1 Digital transformation (DT)

DT can be understood as a dynamic, cumulative process in which the gradual adoption of digital technologies introduces disruptions that lead organisations to reconfigure how they create value. In doing so, they must contend with structural constraints and organisational barriers that shape the outcomes of change, producing effects that may be both beneficial and adverse. This process enables the redesign or change of existing BM within organisations and supports the development of new forms of interaction with customers and stakeholders [14]. From an analytical perspective, DT involves coordinated changes in strategy and processes [15-17]. The SLR’s findings highlight the significance of dynamic capabilities, data-driven strategic, decisions-making and digital ecosystems as fundamental and interrelated dimensions of DT [18-25].

2.2 Business model (BM)

The BM defines the mechanisms by which a company creates, delivers, and captures value. It constitutes a system of interdependent activities that extends beyond organisational boundaries [26] and integrates resources and

processes to promote long-term sustainability, profitability, and growth [27]. Unlike management models that focus on the administration of the organisation (such as quality management systems, frameworks, or business architectures), a BM explains how the company creates and delivers value to generate the revenue needed to cover operations and sustain long-term growth [27,28]. DT enables innovations and changes in BM, including the transformation of the value proposition, the ways that enable revenue generation, and organisational architectures [29-31].

By contrast, management models, such as ISO 9001 or similar quality management frameworks, focus on standardising processes, ensuring compliance, and improving operational consistency, rather than defining how value is created, delivered, and captured. For this paper, innovation in BM is conceptualised as the intentional reconfiguration of the mechanisms through which an organisation creates, coordinates, delivers and captures value, conceived as a continuum ranging from incremental improvements to radical reconfigurations enabled by digital technologies and organisational change [32]. Innovation in BM is not just a process improvement or a product innovation, but a change in the value proposition, revenue and cost structures, key activities and organisational architecture. Within the DiProMo model, innovation in BM is the strategic mechanism that translates DT initiatives into sustainable productivity outcomes.

2.3 Productivity (P)

The P refers to the relationship between the output of a process and the resources used for that output, and serves as a measure of efficiency, rather than just considering the volume of production [26]. At an aggregate level, labour productivity measures output per unit of labour invested, while multifactor productivity (MFP) reflects technological, organisational, and intangible improvements that go beyond the contributions of capital and labour [27, 28], it should be distinguished from production, which refers only to the quantity generated [33-35]. P is chosen as the primary outcome variable of our study as it reflects how well and efficiently an enterprise converts resources into value and does so as opposed to only focusing on short-term financial results or isolated innovation outputs [34-38]. In contrast with just financial performance indicators, productivity measures the structural and operational aspects of DT that improve the processes, organisational learning and the integration of digital capabilities into daily operations.

In addition, P as a measure has a transversal aspect which links technological change with economic performance and is thus quite apt when examining the systemic effects of DT and innovation in BM [36,39]. Taken together, DT, BM and P can be viewed as interrelated but analytically distinct concepts. This means that DT captures the organisational process through which digital technologies are articulated, BM represents the mechanisms that translate these changes into value capture, and P reflects the results of this articulation. Using this integrated framework as a basis, the following section elaborates and formalises the hypotheses that structure the empirical analysis of DT-BM-P relationships.

2.4 Relationships between digital transformation (DT), business model (BM), and productivity (P), and hypothesis testing

The SLR indicates that DT is a multidimensional organisational change that extends the adoption of digital technologies to encompass a strategic reconfiguration of processes, structures, and capabilities [2,7]. The BM provides the mechanisms through which these organisational changes are translated into value creation and capture. Additionally, these transformations influence P outcomes both directly and indirectly. In consequence, these organisational changes raise the need for an empirical analysis of the relationships among these three constructs, considering both the direct effects of DT on P and those mediated by innovation in BM [4, 12]. The links among DT, innovation in BM, and P are based on a common theoretical basis [40-43]. The subsequent hypotheses elaborate specific causal links among the constructs grounded in this shared basis [44].

Relationship between digital transformation (DT) and business model (BM): Existing literature indicates that DT serves as a catalyst for innovation in BM, allowing organisations to reconfigure their value propositions [3, 30]. The literature also suggests that DT supports the exploration of new forms of interaction, supports co-creation with customers and stakeholders, and promotes capacity building in enterprise architecture [45,46]. These mechanisms position DT as a central antecedent of innovation, enabling BM that are more agile, interconnected, and data-driven. Accordingly, the following hypothesis is proposed: H1: DT positively influences innovation in BM (Figure 1).

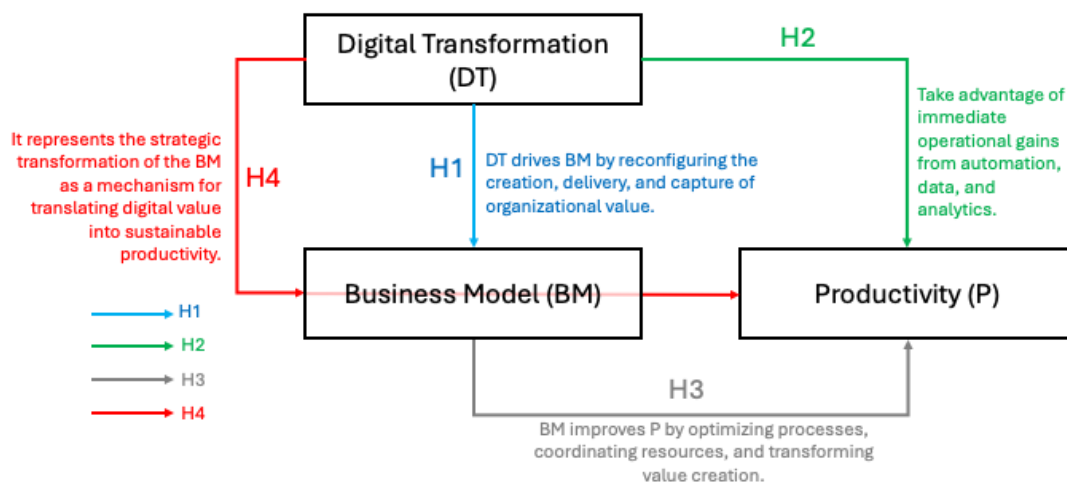


Figure 1. DiProMo model and research hypotheses linking digital transformation (DT), Business model (BM), and productivity (P)

This hypothesis is theoretically grounded in the argument that digital technologies, including analytics, artificial intelligence (AI), automation and Robotic Process Automation (RPA), enable new coordination mechanisms, resources, and activity configurations that foster innovation in BM across organisational contexts and competitive environments [45, 47]. Empirical studies also show that technologies such as advanced analytics and AI enable data-driven redesign of value propositions, while automation and RPA support the reconfiguration of key activities and coordination mechanisms, thereby fostering innovation in BM [45, 48].

Relationship between digital transformation (DT) and productivity (P): Various studies argue that DT generates efficiency and P gains through process automation, reduced transaction costs, and improved data-driven decision-making [33, 49]. However, such gains are only as good as the organisation's capacity to merge digital technology with its structural and cultural components, to optimise digital spending [50]. Empirically, DT can have direct P implications due to operational efficiency, but these benefits will need to be accompanied by mechanisms for long term P to keep up. These mechanisms refer to sustained process efficiency gains enabled by digital integration, improved decision-making based on real-time data and analytics, workforce augmentation through automation, and cumulative learning effects derived from the continuous development of digital capabilities, as documented in prior studies [51]. Hence, the hypothesis H2: DT has a positive and direct impact on P (Figure 1). This result is also consistent with organisational performance theory, which correlates the heavy use of digital technologies with MFP increases and sustained economic value creation [52].

Relationship between business model (BM) and productivity (P): BM serve as the interface between digital strategy and performance outcomes, as they determine how the benefits derived from innovation are created, delivered, and captured [4, 12]. Companies that redesign their business model based on the digital opportunities offered by DT can convert their BM into profits in P, optimizing processes, generating new sources of income, and deepening their competitive advantage [13, 27, 30]. The literature supports the idea that innovation in the BM serves as a mediating mechanism, transforming digital capabilities into measurable performance outcomes. However, prior research also suggests that the P effects of BM may depend on contextual factors such as industry characteristics, regulatory intensity, or the costs associated with organisational reconfiguration, which may temporarily offset efficiency gains in certain settings [53-55]. Consequently, the following hypothesis is proposed: H3: Innovation in the BM has a positive effect on P (Figure 1).

Mediation of the business model and formulation of the causal model: The above arguments suggest that the effect of DT on P is not exclusively direct but also comes through innovation in BM. This partial mediation implies that digitisation produces both immediate operational gains and strategic transformations that amplify its long-term effect [56-58]. Contemporary studies confirm that firms with higher digital maturity achieve superior P outcomes when technological investments are aligned with innovations in value creation and capture [2, 22, 47]. This leads to the final hypothesis: H4: Innovation in the BM partially mediates the effect of DT on P (Figure 1).

3. Method

A sequential exploratory mixed-methods design was employed to support the construction and validation of the DiProMo model. The design permitted the progressive integration of qualitative and quantitative evidence. Four stages were followed in chronological order: a SLR, semi-structured expert interviews, a multisector survey using a Likert-type scale and model estimation using Partial Least Squares Structural Equation Modelling (PLS-SEM).

3.1 Systematic literature review (SLR)

A SLR was conducted following the protocol by Kitchenham in [59]. The SLR was designed to identify documented dimensions, variables, and relationships between DT, BM, and P. Some guiding questions were formulated, such as: How is DT related to innovation in BM? How does innovation in BM influence organisational P? Is there a direct effect of DT on P independent of BM? Does BM act as a partial mediator between DT and P? And what dimensions and variables most strongly explain the links between DT, BM, and P in different sectoral contexts? The search process followed an iterative approach. Searches were undertaken in journals databases such as Scopus, Web of Science, and Emerald Insight, using combined Boolean search strings, adapted to the syntax of each database combining terms related with DT, BM, and P, such as ("digital transformation" OR "digital innovation" OR "digital technologies" OR "digital technology" OR digitalization OR "transformación digital") AND (productivity OR "organizational performance" OR "organisational performance" OR productividad) AND ("business model" OR "business digitization" OR "business digitisation" OR "business model innovation" OR "modelo de negocio").

The documents were selected when they explicitly develop the phenomenon under study and the variables defined in the theoretical framework and when they provided contributions to at least one of the guiding research questions of the review. Included studies had to describe methodological design, internal consistency between objectives, methods and results, and either empirical evidence or rigorous conceptual development. Publications in English and Spanish, published between 2010 and 2024 were included. This temporal inclusion criteria was established because, from a methodological perspective, the concept of DT, understood as a strategic and organisational phenomenon, only became established in academic literature since 2010 [2, 7], whereas previous studies focused mainly on ICT, automation, or information systems, without addressing the integrated reconfiguration of BM, capabilities, and digital ecosystems. Foundational works published prior to this period were incorporated only when they were indispensable for theoretical development. The initial dataset comprised 225 documents. In reading level 1, which involves screening the title, abstract and keywords, 88 documents were selected. Then, in reading level 2, based on full-text analysis aimed to answer the guiding questions, 38 papers were read.

3.2 Semi-structured interviews with experts

Semi-structured interviews were conducted with sixteen experts selected through purposive sampling from energy, finance, health, defence, transportation, information technology, consulting, and academia sectors. All participants, occupied senior executive or high-level managerial positions, including Chief Information Officers, Chief Technology Officers, Chief Digital Officers, innovation directors, senior consultants, principal investigators, and doctoral-level

academic staff. Their profiles reflected a mean professional experience of nineteen years and combined advanced training in engineering, management, economics, and applied sciences with substantive involvement in DT, BM, P analysis, and technological development. Each interview lasted between 90 and 120 minutes and was conducted using a script from the constructs and dimensions identified in the SLR. The sessions were audio-recorded and transcribed with informed consent. The transcripts were analysed using axial coding and constant comparison systematically through Excel, using a tabular structure that allows categories and subcategories to be linked, which allowed recurrent conceptual patterns to be identified, particularly points of convergence between formal definitions and practitioners' perceptions of the constructs, dimensions, and variables included in the model. Through this analytic procedure, coherent relational structures among DT, BM, and P, were documented, providing empirical evidence to support the refinement of the conceptual framework and the clarification of the theoretical foundations of the DiProMo model, including its dimensions and associated variables.

3.3 A multisector survey using a likert-type scale and validation of the instrument

A structured questionnaire consisting of 84 items measured on a seven-point Likert scale was designed to operationalise the core constructs (DT, BM and P) and its dimensions, variables and indicators identified in the previous SLR and semi-structured interviews with experts. A pilot test was conducted with 35 respondents to verify internal consistency using Cronbach's alpha ($\alpha > 0.80$) and to assess collinearity through variance inflation factors (VIF < 5). Following the pilot test, an exploratory factor analysis with Varimax rotation was conducted to refine the measurement instrument. Item retention was guided by standard criteria, including factor loadings of at least 0.60 on the intended construct and the absence of substantial cross-loadings. Items that did not meet these criteria were removed to improve clarity and construct alignment. Following these adjustments, the final survey instrument consisted of 69 items, which were subsequently used in data collection. Consequently, 29 items were used to measure DT, 20 for BM, and 20 for P.

Digital transformation (DT) was measured using perceptual indicators that included digital skills development, sustained technology investment, innovation capacity, strategic alliance formation, market exploration, customer engagement, revenue model innovation, and cost optimisation practices. Business model (BM) was evaluated through perceptual indicators capturing experimentation and resource allocation, strategic alignment, adaptability to market dynamics, implementation and testing of business model changes, innovation intensity, organisational culture, growth performance, market share expansion, speed to market, and return on investment. Performance (P) was assessed using perceptual indicators related to improvements in individual and organisational outcomes, such as skills development through training, efficiency gains, quality of work, adaptability to organisational change, employee satisfaction, process efficiency, use of digital technologies, elimination of non-value-added activities, and enhancements in response times, cost structures, and resource optimisation.

Subsequently, adjustments were made to semantic accuracy and factorial structure following Varimax rotation and validation by experts. The final version of the survey was administered to a sample of 318 professionals and managers

from organisations that were carrying out DT processes. All responses were reviewed for completeness, normality, and multicollinearity prior to quantitative modelling. The suitability of the sample size for PLS-SEM was assessed following the 10-times rule, which recommends a minimum sample size equal to ten times the maximum number of structural paths pointing at any latent construct. In the DiProMo model, the most complex endogenous construct receives two incoming paths, implying a minimum required sample size of 20 observations. The final sample of 318 valid responses substantially exceeds this threshold, supporting the robustness of the PLS-SEM estimation.

The study draws on a multisectoral sample to identify generalisable patterns in the relationships among DT, BM, and P. The use of P measures is consistent with previous research on organisational performance and DT [40, 60], especially in multisectoral and interorganisational studies where access to objective and homogeneous P data is limited. Sectoral differences were not modelled explicitly, and the data were analysed as a pooled, consistent with the objective of validating a general explanatory model rather than examine sector-specific effects. This phase provided a validate dataset suitable for statistical analysis and supported the consolidation of version 0.3 of the DiProMo model.

3.4 Estimation using PLS-SEM modelling

Partial Least Squares Structural Equation Modelling (PLS-SEM) was performed using SmartPLS 4 following the guidelines provided by Hair in [57, 61] and by Muñoz-Martinez et al in [60]. This approach was selected due to its suitability for explanatory and predictive analysis in emerging models, its flexibility regarding distributional assumptions, and its robustness when applied to moderate samples, non-normal data, and partial mediations such as the DT-BM-P relationship [57, 62]. In the measurement model, all three core constructs, DT, BM, and P, were specified as reflective constructs, assuming that the observed indicators represent manifestations of the underlying latent variables and are therefore expected to covary. The analysis assessed convergent and discriminant validity through average variance extracted (AVE) and heterotrait-monotrait ratio (HTMT), examined composite reliability, and evaluated collinearity through VIF. Direct and indirect structural paths linking DT, BM, and P were estimated and the DiProMo model's predictive capacity was evaluated in accordance with established PLS-SEM criteria.

4. Results

4.1 Results of the SLR

The SLR provided a comprehensive theoretical framework for analysing the relationships between DT, BM, and P. From the 38 documents analysed, the definitions of the three central constructs (DT, BM, and P) and nine key dimensions were identified, namely: digital capabilities, digital strategy and leadership, culture and change management, digital value proposition, organisational and operational architecture, value capture and delivery mechanisms, operational efficiency, organisational effectiveness and performance, and innovation and continuous improvement. The reviewed studies indicated that DT acts as a cross-cutting enabler that reconfigures the value proposition, processes, and business structure [63,64] that innovation in BM mediates the translation of digital capabilities into tangible results [4, 12, 30] and that P represents the observable results of this articulation [27-29, 41, 63]. The literature documented direct and mediated

relationships between DT and P, supporting the relevance of the causal structure model of the form DT→BM→P. Table 1 presents the initial configuration of the DiProMo model (version 0.1), in which indicators are districted across nine dimensions associated with DT, BM, and P. This configuration was derived from the synthesis and coding constricts and dimension reported in the literature [46].

Table 1. Indicators distributed across the nine dimensions of the DiProMo model (version 0.1) [65]

Construct	Dimension	Associated indicators
Digital Transformation (DT)	1. Digital Governance	-Formal digital strategy. -CIO/CDO leadership. -Business-IT alignment. -Data governance framework. -Security and privacy policies.
	2. Digital culture	-Innovative mindset. -Openness to change. -Continuous learning. -Digital skills of staff. -Interdepartmental collaboration.
	3. Infrastructure and Automation	-Data quality and interoperability. -Systems integration. -IT investment. -Level of automation and use of AI/RPA. -Organisational cybersecurity.
Business Model (BM)	4. Value proposition	-Digitisation of products/services. -Personalization of the offering. -Value perceived by the customer. -Sustainability of the proposition.
	5. Revenue Structure	-Diversification of revenue sources. -Data monetization. -Use of platforms and ecosystems. -Subscription or freemium models.
	6. Customer Experience and Relationship	-Omnichannel approach. -Seamless digital experience. -Satisfaction and engagement levels. -Loyalty programs.
Productivity (P)	7. Labor productivity	-Output per hour/worker. -Performance per employee. -Innovation in work methods. -Use of digital tools.
	8. Operational Efficiency	-Reduction in cycle times. -Unit costs and process efficiency. -Level of rework or defects. -End-to-end integration.
	9. Financial and Competitive Results	-Incremental operating margin. -Return on digital assets (RODA). -Time-to-market. -Gross value added (GVA) growth.

4.2 Results of the Semi-Structured Interviews

Semi-structured interviews with 16 experts from industry and academia were used to validate and enrich the results of the SLR. The participants represented sectors such as energy, finance, health, defence, transport, information technology, consulting, and higher education, and all occupied senior executive or high-level managerial roles.

Across the interviews, DT was consistently described as a strategic process that transcends operational digitisation and entails changes in organisational strategy and culture. Twenty-seven key variables were identified and organised into the three constructs, as shown in Table 2. These variables characterise the organisation’s ability to align digital strategy with value proposition and technology governance. Table 2 summarises the constructs and associated variables that informed version 0.2 of the DiProMo model, which introduced a more integrated architecture derived from expert consensus, with concordance coefficient >0.75 according to Muñoz-Martínez et al in [66]. The interviews therefore contributed to consolidating a set of operational variables for DT, BM, and P, which were subsequently operationalised in the survey instrument.

4.3 Results of the likert-type survey

The survey was completed by 318 professionals and managers in organisations undergoing DT processes. The data allowed the relationships between the variables identified in the previous stages to be quantified. Reliability analyses indicated high internal consistency, with Cronbach's α coefficients above 0.85 for all constructs and factorial validity indices such as the Kaiser- Meyer-Olkin (KMO) above 0.8. Descriptive statistics showed that organisations reporting higher levels of digital maturity tended also to report greater innovation capacity in their BM and better P indicators. Bivariate correlations between the DT, BM, and P, were positive and statistically significant, consistent with a mediation pattern in which BM acts as an intermediary between DT and P. These empirical results supported the refinement of the DiProMo model to version 0.3 and provided the foundations for structural analysis using PLS-SEM.

4.4 PLS-SEM estimation results

The structural model was estimated using PLS-SEM in SmartPLS 4, taking as reference the relationships specified between DT, BM, and P. The results confirm that DT operates as a strong exogenous driver of BM through innovation, with a high and statistically significant path coefficient ($\beta = 0.783$, $p < .001$). This finding supports the interpretation that DT precedes and enables transformations in value creation and capture, along with companies' operational architecture, positioning BM as the main mechanism through which digital potential is translated into organisational results. In addition, the estimation reveals a direct and positive effect of DT on P ($\beta=0.734$, $p<.001$), indicating that automation, data exploitation, and analytics can generate immediate efficiency gains. However, innovation in the BM also shows a strong and significant effect on P ($\beta=0.755$, $p<.001$), confirming its role as a central performance lever. The mediation analysis evidences a robust partial mediation pattern, where the indirect effect of DT on P through the BM (approximately 0.214) is comparable in magnitude to the direct effect (approximately 0.216). This result indicates that an important portion of the P impact of DT is channelled through BM redesign, without eliminating its direct operational contribution.

Table 2. Constructs and variables of the DiProMo model validated in expert interviews

Construct	General description	Associated variables
1. Digital Transformation (DT)	The organisation's ability to integrate digital technologies into its strategy, structure, and processes, generating new capabilities and value dynamics.	1.Integrated digital strategy. 2.Data and technology governance. 3.Digital leadership. 4.Culture of change and learning. 5.Digital talent capabilities. 6.Technological infrastructure. 7.Use of analytics and AI. 8.Process automation.
2. Business Model (BM)	Mechanisms through which the organisation redefines its value proposition, delivery, and capture by leveraging digital technologies.	9.Digital value proposition. 10.New revenue mechanisms. 11.Redesign of key processes. 12. Co-creation with customers. 13.Digital ecosystems and alliances. 14. Organisational agility. 15.Capacity for experimentation. 16.Continuous innovation.
3. Productivity (P)	Observable result of the articulation between DT and BM, measured in efficiency, effectiveness, and sustainable performance.	17.Operational efficiency. 18.Cost reduction. 19.Improved response times. 20.MPF 21.Economic value creation. 22.Customer satisfaction. 23.Financial performance. 24.Organisational competitiveness. 25.Adaptability to the environment. 26.Sustainable innovation. 27.Organisational learning.

Model quality indicators further support the robustness of the estimation. The overall goodness of fit is acceptable, with an SRMR value of 0.069, below the recommended threshold of 0.08. Predictive relevance is also high, as reflected by Q² values of 0.605 for BM and 0.533 for P. Taken together, these results empirically validate the hypothesised relationships between DT, BM, and P, and provided empirical support for the DiProMo model.

4.5 Measurement model

The measurement model was evaluated under the consolidated standards of PLS-SEM [57]. Internal reliability was verified using Cronbach's α and composite reliability (CR), both of which exceeded the recommended thresholds of 0.70 for all constructs. Convergent validity was confirmed through average extracted variances (AVE ≥ 0.50), and

discriminant validity was assessed using the Fornell-Larcker criterion and the HTMT index, which remained below 0.85. External loadings (λ) were above 0.70 for most indicators, and the cross-loadings did not reveal multicollinearity issues. Table 3 summarises the internal reliability and convergent validity results for the three latent constructs of DT, BM, and P, ensuring that each robustly represents the theoretical dimension for which it was designed.

Exploratory and confirmatory factor analyses (EFA and CFA) were also conducted to validate the factorial structure of the constructs. The KMO indices ranged from 0.930 to 0.946, with significant Bartlett's tests (p < 0.001), which confirmed the suitability of the data for multivariate analysis. Factor rotations showed high loadings and stable three-constructs structures, explaining more than 65%. For the BM construct, the explained variance was 66.57%, for DT it was 70.82%, and for P it was 69%, as shown in Table 4.

Table 3. Internal reliability and convergent validity of the measurement model constructs

Construct	Cronbach's α	CR	AVE	HTMT (<0.85)	λ (range)
DT	0.94	0.95	0.71	Compliant	0.72–0.88
BM	0.96	0.97	0.70	Compliant	0.70–0.89
P	0.93	0.95	0.69	Compliant	0.71–0.87

Note: All α and CR values exceed the threshold of 0.70. AVE meets the criterion of ≥0.50. The HTMT index remained below 0.85, and external loadings (λ) were greater than 0.70 for most items [65].

Table 4. Results of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA)

Construct	KMO	Bartlett (p)	Explained variance (%)
DT	0.946	< 0.001	70.82
BM	0.930	< 0.001	66.57
P	0.930	< 0.001	69.00*

Note: All KMO indices exceed the threshold of 0.80, confirming sample adequacy. Bartlett's test was significant (p < 0.001), indicating sufficient correlations between items. Explained variances are greater than 65%, ensuring factorial stability [65].

The robustness of the measurement model was examined using bootstrapping with 5,000 subsamples, which confirmed the statistical significance of the external loadings and the stability of the parameter estimates. It also indicated DT strongly shaping of innovation in BM and exerting a direct effect on P, as shown in Table 5. The BM likewise demonstrates a substantial influence on P, reinforcing the model's coherence and explanatory power within the structural analysis.

The significance of the indirect effect was further supported by bootstrapping results, which confirmed that the indirect path from DT to P via innovation in BM was statistically significant, reinforcing the partial mediation conclusion. The model shows an acceptable global fit, with SRMR below the threshold and the VIF remained below 5, suggesting the absence of collinearity, as shown in Table 6. The Q² coefficients for the BM and P demonstrate strong predictive validity, suggesting the structural model offers robust explanatory and forecasting capacity.

Table 5. Bootstrapping results and measurement model adjustment

Relationship	β (O)	Mean (M)	STDEV	t	p	Interpretation
DT → BM	0.783	0.396	0.022	17.544	0.000	Highly significant
DT → P	0.734	0.214	0.044	4.864	0.000	Significant, direct impact
BM → P	0.755	0.546	0.080	6.756	0.000	Significant and strong

Table 6. Overall adjustment indicator

Index	Value	Criterion	Result
SRMR	0.069	< 0.08	Acceptable fit
Q ² (BM model)	0.605	> 0	High predictive validity
Q ² (Productivity)	0.533	> 0	High predictive validity
VIF	< 5	< 5	No collinearity

4.6 Structural model

The structural model depicted in Figure 2 presents the causal architecture linking the three core constructs, DT, BM, and P. The structural relationships between DT, BM, and P, which were evaluated in line with the hypothesis H1 – H4. The results showed that DT exerted a strong and significant effect on BM (H1: DT→BM, $\beta = 0.783$, $p < .001$), BM had a strong and significant effect on P (H2: BM→P, $\beta = 0.755$, $p < .001$), and DT had a significant direct effect on P (H3:DT→P, $\beta = 0.734$, $p < .001$). In addition, DT had a meaningful indirect effect on P through BM (~ 0.214), which was comparable to the direct effect (~0.216), supporting the presence of partial mediation (H4).

The mediating role of innovation in BM was further assessed using the variance accounted for (VAF). The ratio of the indirect effect of DT on P via BM (~ 0.214) to the total effect (~ 0.430) yielded a VAF of around 50%, which was consistent with partial mediation, according to established PLS-SEM criteria, as both direct and indirect paths remained statistically significant. The model demonstrated adequate explanatory and predictive performance. The overall fit was adequate with SRMR = 0.069, and Q² for BM = 0.605; Q² for P = 0.533, as shown in Figure 1, and Table 5 and Table 6.

The explained variance values indicate that the model captures a substantial share of the dynamics of BM and P. The R² values (within the blue circles in Figure 2), 0.613 for BM and 0.623 for P, show that the model accounts for a substantial proportion of variance in both constructs. The magnitude and significance of the structural paths confirm a coherent causal architecture consistent with the theorised mediation mechanism. The measurement model, also depicted in Figure 2 and detailed in Error! Reference source not found., shows the observable indicators (yellow rectangles) for each construct. DT is measured through fourteen reflective indicators capturing adoption, use, and management of digital technologies. The BM construct comprises a broad set of reflective indicators grouped into dimensions of value proposition innovation, value capture mechanisms, key activities, and organisational architecture.

P is assessed through twenty reflective indicators covering costs, efficiency, man hours, operational performance, and results. The majority of the external factor loadings (λ) (indicated by the arrows in Figure 2) which reflect the contribution of each item to its underlying construct, exceeded the recommended threshold of 0.70, providing evidence of convergent validity and supporting the multidimensional structure of the constructs.

4.7 Relationship between constructs

Empirical analysis confirms that DT acts as a strategic lever that drives innovation in BM and, through this, P. DT reconfigures the mechanisms of value creation, delivery, and capture, which are at the core of BM, and also generates immediate operational improvements. Together, both channels explain the observed performance increases. This DT→BM→P articulation is consistent with contemporary frameworks of digitisation, innovation, and organisational performance [2, 4, 7].

Digital transformation → Business model: DT is modelled as an exogenous variable that significantly enhances innovation in the BM. PLS-SEM estimates report a high effect ($\beta = 0.783$, $p < .001$), validating that DT precedes and enables substantive changes in the value proposition, revenue capture mechanisms, and the operational architecture of the business. In this regard, we can say that BM is the first step that enables the digital potential applied in the organisation to be translated into performance results, thereby consolidating its strategic role.

Digital transformation → productivity: However, in addition to BM mediation, DT also has a direct effect on P. The structural model confirms a positive impact ($\beta = 0.734$, $p < 0.001$), although of lesser magnitude than that mediated by innovation in BM. This finding shows that process automation, intensive data use and analysis generate immediate operational efficiencies; however, the sustainability of these positive results depends on their ability to articulate with changes in BM, which reinforces the importance of managing DT as an integral process and not just a technological or resource-related one [31, 47].

Business model → productivity (and BM mediation): The innovation in BM confirms its influence on P, with a coefficient of $\beta = 0.755$, $p < 0.001$. This shows that the results validate a consistent pattern, namely that the indirect effect of DT on P through BM (~0.214) is comparable to the direct effect (~0.216), demonstrating that much of the impact of DT reaches P through the redesign of BM, without neglecting its direct contribution. The overall fit of the model (SRMR=0.069<0.08) and the high predictive relevance (Q²_BM=0.605; Q²_P=0.533) reinforce the methodological soundness and practical usefulness of the model proposed by Giraldo-Ríos in [65].

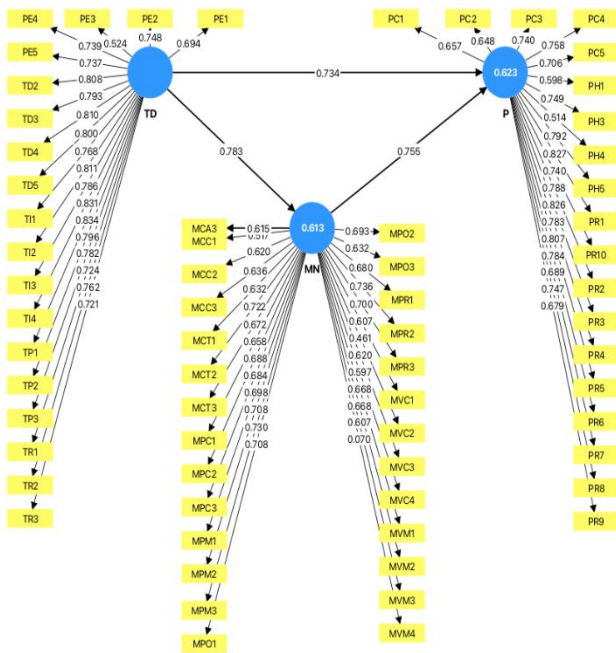


Figure 2. Graph of the PLS_SEM structural model DiProMo model

5. Discussion

The model proposed shows strong construct validity. The R² coefficients for the BM (0.613) and P (0.623) show a highly explanatory capacity. The global fit indicators, including an SRMR of 0.069 and Q² values exceeding 0.50, confirm the model’s predictive quality. The structural configuration shows both direct and mediated effects. Direct effects from DT to P (DT → P) and mediated effects operating through the BM (DT → BM → P). Both effects support that P gains arise chiefly through innovation in BM enabled by DT. In contrast to the existing DT performance frameworks, which often emphasise the direct relationships between digital technologies and performance outcomes, the DiProMo model explicitly characterises innovation in BM as a mediating mechanism by which DT affects P. As such, this not only offers more nuanced explanations than those reliant solely on linear or technological perspectives but also identifies the organisational processes through which digital investments lead to performance enhancements [60, 67].

Moreover, unlike previous SEM-based models that typically analyse DT dimensions as independent predictors of performance, the DiProMo model integrates DT, BM, and P into a coherent causal architecture validated through PLS-SEM [67]. The model combines reflective constructs grounded in theory with high predictive relevance, allowing it to function not only as an explanatory framework but also as a predictive tool for assessing how DT initiatives generate value through BM reconfiguration. The empirical findings also support the theoretical expectations of dynamic capabilities and resource-based approaches, as P improvements are not only driven by digital assets per se, but by the organisation’s ability to reconfigure its BM. The partial mediation effect detected corresponds to views from both the socio-technical and ecosystem perspectives on the consequences of DT as products of the interaction among the technological, organisational, and relational dimensions. While alternatives such as financial performance, innovation outputs, or sustainability indicators are also the norm in the literature of DT, P was chosen for this research as an

intermediate and integrative construct. Often P improvement occurs before and allows better financial results, innovation ability, and long-term sustainability. From a forward-looking perspective, P reflects the organisation’s ability to convert digital investments and BM reconfigurations into scalable and sustainable performance improvements, aligning with the long-term orientation of DT.

Table 7. Observable items of the DiProMo model constructs

Construct	Item code	Description / Dimension	Type
DT	DT1 – DT14	Indicators of adoption, use, and management of digital technologies	Reflective
BM	MBI1 – MBI27 (MCA1–MCA3, MCC1–MCC3, MCT1–MCT3, MPC1–MPC3, MPM1–MPM3, MPO1–MPO3, MPR1–MPR3, MVC1–MVC4, MVM1–MVM4)	Dimensions of innovation in the value proposition, capture mechanisms, key activities, and organisational architecture	Reflective
P	P1 – P20 (e.g., PC1–PC5, PE1–PE5, PH1–PH5, PR1–PR10, TR1–TR3)	Organisational performance indicators: costs, efficiency, man-hours, performance, and results	Reflective

The results are consistent with four hypotheses proposed in the study. First, H1, by also demonstrating that DT significantly induces innovation in the BM ($\beta = 0.783, p < .001$). Second, H2 by establishing direct effects of DT on P with H3 ($\beta = 0.734, p < .001$). Third, H3 by showing that innovation in the BM more strongly increases P ($\beta = 0.755, p < .001$). And H4, indicating partial mediation, in that, as a result of DT in the BM, the indirect effect of DT (~0.214 vs. ~0.216) through BM has the same strength as a direct one. This arrangement not only complements the theoretical aspects but also reaffirms the guiding logic of the DiProMo model: P expands when these investments align with innovations in the BM where operational excellence and organisational architecture are integrated.

Furthermore, the measurement model offers the possibility of applying its results as a repeatable and credible benchmark for analysing causal and predictive models of the influence of digital technology and innovation in the BM, and for answering empirical questions about the relationship between these dimensions and P, as well as the proposed models of P. The quality of the DiProMo model is sufficient to support the testing of the hypotheses of the current research, as well as to provide a model-oriented theoretical basis in other fields, methodologically advancing research on the relationship between digitalisation and strategic redesign, and its impact on organisational performance. However, if digital technology is taken to an abstract level, it is unlikely that P will increase sustainably, since it will only be maintained if BM are redesigned to encompass the value resulting from digital technologies [4, 30, 47]. The findings

indicate the existence of two complementary channels: one is a direct operational gain driven by automation, data, and analytics, and the other is a strategic gain through changes in value proposition, capture, and operational architecture [31, 68].

These results are consistent with recent literature in the Digital Economy [44], that emphasizes the influence of organisational capabilities and BM's alignment in adopting digital technologies to improve MFP. Theoretically, it applies dynamic capabilities and an ecosystem perspective to the analysis of innovation in BM. It also provides a replicable, model-based PLS-SEM protocol for analysing the DT-BM-P nexus. From a management perspective, the results underscore the importance of prioritizing digital strategies in a way that explicitly indicates their role in BM and P, structuring business case analyses that articulate the causal pathways from DT to P through BM, and connecting investments with intermediate BM metrics, including value proposition, revenue mechanism, customer experience, end to end, redesign, and standardized P metrics, including cycle times, hourly output, first-pass yield, and incremental margin.

6. Limitations

Despite its contributions, this study presents several limitations. First, the empirical analysis is based on self-reported, perceptual data collected through a survey. Although this approach is widely used in DT research and is valuable for collecting assessments from managers across multiple sectors, it can introduce respondent-related bias. To mitigate this risk, the study focused on professionals with experience in senior management or managerial positions and applied recognised reliability and validity procedures within the PLS-SEM framework.

In addition to the above, the study employs a cross-sectional design, which limits the ability to infer causal relationships over time. Although the theoretical model specifies the direction of the relationships between DT, BM, and P, these relationships would benefit from further longitudinal examination. The use of a single survey instrument may raise concerns about common method bias. This risk was mitigated through careful questionnaire design and construct specification, while the robustness of the measurement model provides an additional safeguard against common method bias. Finally, although the multi-sector nature of the sample reinforces the conceptual generalisation of the DiProMo model, the specific characteristics of each sector may influence the magnitude of the observed relationships. Consequently, the results should be interpreted as reflecting a general mechanism rather than sector-specific effects.

7. Conclusions

The DiProMo model demonstrates that the benefits of P arise when investment is accompanied by innovation in the BM, and not just as a technological improvement. The structure of the model, which incorporates both direct and mediated channels, highlights DT as a strategic driver whose effects materialise through the renewal of value creation and capture and organisational architecture. The partial mediation identified reinforces the idea that operational improvements derived from digitalisation (automation, data and analytics) must be integrated with organisational redesigns aimed at creating and capturing value to generate sustainable increases in P. The model's high predictive power (SRMR=0.069; $Q^2>0.50$) confirms its empirical robustness. The main contribution of this paper is the validation of the

DiProMo model using reflective constructs in PLS-SEM in SmartPLS 4, providing a replicable methodological framework that can be applied throughout organisations of varying degrees of digital maturity. Given the testing of the four hypotheses (H1 to H4), we can confirm that investments in DT are most beneficial when directly included in innovations in BM. This DT → BM → P link serves as an analytical framework for companies interested in governing their competitiveness in rapidly evolving environments and for decision-makers to design strategies that accelerate digital and organisational development. The study's limitations point to opportunities for future research. Future studies could expand empirical coverage by incorporating a longitudinal design, objective performance measures, and conducting sectoral or comparative analyses and exploring non-linear, hierarchical, or quasi-experimental models to strengthen the explanatory scope and robustness of the DiProMo model. Longitudinal designs would allow for the examination of temporal changes in DT, innovation in BM, and P analysing their dynamics and causal feedback loops, which cross-sectional approaches cannot fully account. Such approaches would be particularly valuable for analysing the evolution of digital initiatives and their sustained impact on P outcomes. In addition, the model could be extended by incorporating others outcome variables, such as sustainability performance, ESG indicators, or social value creation, to assess how DT and innovation in BM contribute to organisational and societal objectives. Moreover, applying the DiProMo model to emerging technological contexts, such as native AI-driven firms, Industry 5.0 contexts or digitally born platforms, might enhance the understanding of how advanced technologies influence mechanisms of value creation and performance outcomes. Complementary sector-specific and multi-group analyses could refine DiProMo's model explanatory power and provide insights to inform context-relevant DT strategies. Such extensions would support the model's continued relevance as a flexible and future-oriented framework for future research in the field of digital economy.

Ethical issue

The authors are aware of and comply with best practices in publication ethics, specifically regarding authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with research ethics policies. The authors adhere to publication requirements that the submitted work is original and has not been published elsewhere.

Data availability statement

The manuscript contains all the data. However, more data will be available upon request from the authors.

Conflict of interest

The authors declare no potential conflict of interest.

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