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QUANTUM MARKETING IN E-COMMERCE

The high rate of business digitalisation has increased the necessity of sophisticated marketing mechanisms capable of shaping intricate, specific and contextual consumer decision-making procedures. The traditional linear marketing models are less effective in accounting for the behavioural dynamics in the algorithmically mediated and information-saturated digital world. The empirical gap addressed in this study concerns the economic and behavioural efficacy of quantum marketing mechanisms in electronic commerce. The hypothesis of the study is that increasing the intensity of quantum marketing in e-commerce has a positive but nonlinear impact on economic performance of companies, which is mediated by changes in consumer behaviour and is amplified in conditions of market uncertainty. The study determines the extent to which the intensity of quantum marketing influences consumer buying behaviour and company performance both in nonlinear and interactive as well as state-dependent ways. The paper uses a multi-country panel model of e-commerce companies from 2020 to 2024. An overall index of Quantum Marketing Intensity is created to reflect the depth of personalisation, adaptivity in real-time, coordination between channels, and intensity of experimentation. They use fixed-effects panel econometric models that include behavioural mediation, nonlinear specifications, and terms of interaction that are used to indicate contextual volatility. The statistical results indicate that the intensity of quantum marketing has a positive and statistically significant effect on conversion rates, revenue per visit, gross margin, and customer lifetime value. The evidence suggests diminishing marginal returns, which confirms the nonlinear nature of advanced marketing

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КВАНТОВИЙ МАРКЕТИНГ В ЕЛЕКТРОННІЙ КОМЕРЦІЇ

Високі темпи цифровізації бізнесу посилюють потребу у складних маркетингових механізмах, здатних формувати виважені, визначені та контекстуальні процедури прийняття рішень споживачами. Традиційні лінійні маркетингові моделі дедалі менш ефективні, враховуючи динаміку поведінки в алгоритмічно опосередкованому та інформаційно насиченому цифровому світі. Емпірична прогалина, яку враховано в цьому дослідженні, пов'язана з економічною та поведінковою ефективністю квантових маркетингових механізмів в електронній комерції. Дослідження ґрунтується на гіпотезі, що підвищення інтенсивності квантового маркетингу в електронній комерції має позитивний, але нелінійний вплив на економічні результати компаній, які опосередковуються змінами споживчої поведінки та посилюються в умовах ринкової невизначеності. Визначено, якою мірою інтенсивність квантового маркетингу впливає на купівельну поведінку споживачів та ефективність компаній як нелінійним, так і інтерактивним, а також залежним від стану способом. Використано багатонаціональну панельну модель компаній електронної комерції за 2020 та 2024 рр. Створено загальний індекс інтенсивності квантового маркетингу для відображення глибини персоналізації, адаптивності в режимі реального часу, координації між каналами та інтенсивності експериментів. Вони використовують панельні економетричні моделі з фіксованими ефектами, що включають поведінкове посередництво, нелінійні специфікації та умови взаємодії для позначення контекстуальної волатильності. Статистичні результати показують, що інтенсивність квантового маркетингу має позитивний та статистично значущий вплив на коефіцієнт конверсії, дохід на відвідувача, валовий прибуток та довічну цінність клієнта. Дані свідчать про зниження граничної



mechanisms. The evidence shows that marginal returns are decreasing, which proves the nonlinearity of marketing mechanisms. The economic outcomes are mediated by behavioural variables that explain the effects of specific characteristics, with variables explaining approximately one-quarter to one-third of all effects. The combined effects of digital channels are positive, highlighting the need for synchronised omnichannel strategies. Market volatility enhances the effectiveness of quantum marketing, particularly under increased uncertainty, which supports the contextual dependency hypothesis. The analysis shows that its effectiveness peaked in 2022 and subsequently stabilised as markets matured and consumers became more accustomed to digital interactions. Overall, the study makes a scientific contribution by demonstrating the quantification of marketing as a quantitatively measurable econometric approach and the possibility of its integration with the tools of behavioural economics and panel econometric analysis. The results provide a basis for further research into quantum marketing in e-commerce, particularly for analysing customer data and applying experimental algorithms in digital sales channels.

Keywords: quantum marketing, electronic commerce, consumer behaviour, digital personalisation, nonlinear marketing effects, omnichannel strategy, panel econometric analysis.

прибутковості, що підтверджує нелінійний характер дії передових маркетингових механізмів. Отримані результати також демонструють, що економічні ефекти реалізуються через поведінкові змінні, які відображають вплив певної специфіки та сукупно пояснюють приблизно від чверті до третини всіх ефектів. Синергія ефектів між цифровими каналами є позитивною, і важливо відзначити необхідність синхронізованих омніканальних стратегій. Волатильність ринку підвищує ефективність застосування квантового маркетингу, особливо за умов зростаючої невизначеності, що підтверджує гіпотезу контекстної залежності. Дослідження показує, що його ефективність була максимальною у 2022 р., а згодом стабілізувалася, у міру того як ринки ставали більш зрілими, а споживачі більш адаптованими. Загалом дослідження робить науковий внесок, демонструючи квантифікацію маркетингу як кількісно вимірюваного економічного підходу та можливості його інтеграції з інструментарієм поведінкової економіки і панельного економічного аналізу. Отримані результати створюють основу для подальших досліджень квантового маркетингу в електронній комерції, зокрема для аналізу клієнтських даних, застосування експериментальних алгоритмів у цифрових каналах збуту.

Ключові слова: квантовий маркетинг, електронна комерція, поведінка споживачів, цифрова персоналізація, нелінійні маркетингові ефекти, омніканальна стратегія, панельний економічний аналіз.

JEL Classification: M31, D12, D91, L81.

Introduction

The high growth rate of electronic commerce has increased competition levels and firms are seeking the best new marketing mechanisms that can be used to affect complex and uncertain consumer decision-making processes (Konopliannykova, 2024). Conventional linear marketing frames are becoming less relevant for describing observed consumer behaviour in digitally saturated contexts of information overload, algorithmic mediation and volatile contextuality. In that regard, quantum marketing becomes a promising paradigm with the focus on probabilistic choice, nonlinear effects, contextuality, and interaction among the multiple digital stimuli. Although both conceptual and behavioural interest in quantum marketing mechanisms is increasing, empirical evidence on their economic and behavioural efficiency remains inconsistent and methodologically underdeveloped.

The rapid expansion of digital commerce and data-driven marketing has increasingly exposed the limitations of traditional linear models of consumer choice and firm performance. Recent theoretical advances

emphasise nonlinear and probabilistic perspectives on economic decision-making. Zheng and Bai (2024) demonstrate that market dynamics may exhibit threshold effects and discontinuities that cannot be captured by smooth linear adjustments, a logic that is directly applicable to digital marketing contexts characterised by personalisation and adaptive targeting. Broader research on quantum computing and post-quantum technological systems further supports this departure from deterministic causality, highlighting contextual dependence, uncertainty, and multi-dimensional interaction structures in complex decision environments (Memon et al., 2024; Shamsuddoha et al., 2025; Kuka et al., 2026). These studies provide a conceptual foundation for interpreting advanced digital marketing as a probabilistic and nonlinear system.

Empirically, capturing such complexity requires econometric approaches that account for unobserved heterogeneity, indirect effects, and diminishing returns. Applied economic research demonstrates the suitability of panel models with fixed effects and nonlinear specifications for analysing strategic decisions under uncertainty. Mazur et al. (2023) show that firm-level outcomes are governed by structurally nonlinear relationships, while Prokopenko et al. (2024) emphasise that economic effects often materialise through combined direct and mediated channels. In the marketing domain, Kazibudzki and Trojanowski (2024) confirm that marketing effectiveness is best evaluated through integrated quantitative frameworks linking behavioural adjustments to economic performance.

Behavioural studies of digital consumption further reinforce the systemic nature of marketing outcomes. Peer influence, product type, and social context significantly shape online purchase decisions, particularly among younger consumers (Theocharis, 2025). Spatial and location-based factors also moderate the effectiveness of digital marketing, underscoring the importance of contextual variation (Theocharis et al., 2025). Comparative evidence from European e-commerce markets reveals substantial cross-country heterogeneity in online consumer behaviour, suggesting that responses to digital stimuli are neither uniform nor stable across institutional settings (Madlenak et al., 2025). Moreover, integrity- and trust-based interactions function as key behavioural transmission mechanisms through which marketing efforts influence purchase intentions (Florea et al., 2025).

Parallel evidence from the literature on artificial intelligence and data-driven marketing illustrates how adaptive mechanisms operate in practice. AI-driven marketing tools are shown to increase e-commerce sales, yet their effectiveness diminishes as algorithmic complexity intensifies, indicating the presence of decreasing marginal returns (Madanchian, 2024). Systematic reviews of emerging technologies in e-commerce identify personalisation, experimentation, and omnichannel coordination as dominant trends, while also highlighting the growing difficulty of managing their combined effects within linear frameworks (Sandu et al., 2025). Advances in big data analytics,

including the use of synthetic and high-dimensional data, further complicate the marketing-performance relationship by amplifying uncertainty and reinforcing the need for adaptive strategies (Theodorakopoulos et al., 2026).

Foundational studies on digital marketing provide the baseline for understanding these advanced mechanisms. Early research conceptualises digital marketing as an innovative communication and coordination tool that restructures firm–consumer interactions (Holovchuk et al., 2018). Subsequent work positions digital marketing as a central component of modern business strategy, particularly in competitive and technologically dynamic environments (Goriashchenko & Ilchenko, 2020; Pertsova, 2020). Strategic analyses of e-commerce firms further indicate that marketing behaviour reflects adaptive responses to market conditions rather than static optimisation processes (Svobodová & Rajchlová, 2020).

Overall, the literature converges on the conclusion that digital marketing effectiveness is nonlinear, behaviourally mediated, and context-dependent. Economic outcomes are shaped not only by the intensity of marketing mechanisms but also by behavioural transmission channels, interaction effects, and market volatility. These insights directly motivate the empirical framework adopted in this study, which models quantum marketing intensity as a composite construct, incorporates behavioural mediation, and explicitly accounts for nonlinear and context-dependent effects within a multi-country panel setting.

The main research question that has been considered in this study is how little has been done to econometrically validate the linkage between quantum marketing processes and quantifiable behavioural and economic returns in e-commerce. The available literature is mainly centred on single tools, such as personalisation or omnichannel strategies, without paying any attention to the combined, nonlinear, and state-dependent effects of these methods. This void limits theoretical knowledge and managerial advice on how best to use advanced digital marketing processes in terms of both intensity and coordination.

The objective of the study is to empirically evaluate the processes by which quantum marketing impacts e-commerce performance both behaviourally and economically. The aims are to create a composite quantum marketing intensity index, approximate non-linear effects of the same, and the channels of mediation of behaviour. The other aims include describing the effects of interaction between the digital medium and evaluating the impact of market volatility on enhancing the marketing performance. According to the theoretical framework, the hypotheses that were tested in the study are positive direct effects, mediation by behaviour, decreasing returns, and amplification.

The central hypothesis of this research is that quantum marketing, understood as a set of adaptive, personalised, and context-dependent digital mechanisms, exerts a statistically significant influence on consumer

behaviour and the economic performance of e-commerce firms. It is further hypothesised that this influence is nonlinear, characterised by diminishing marginal returns at higher levels of marketing intensity, partially mediated by behavioural variables, and strengthened in periods of elevated market volatility.

The study relies on a multi-country panel econometric model, which will be applied to firm-level data on international e-commerce companies from 2020 to 2024 to test the empirically proposed hypothesis. This methodology is a combination of fixed-effects panel regression, mediation estimation, nonlinear specifications, and interaction terms to estimate the mechanisms of behavioural transmission and context-specific effects. Due to the intricacy of the econometric design and the development of the composite indices, the methodological design is described in detail in a dedicated section.

The novelty of this study is the combination of quantum marketing theory and econometric panel modelling using secondary multi-country data. Unlike previous work, the analysis of non-linearities, interaction effects and time-varying dynamics are captured in a unified empirical framework. The study contributes to the marketing and digital economics literature through the operationalisation of quantum marketing as an economic concept. From a practical point of view, the results give evidence-based information on how to strategically calibrate advanced marketing mechanisms in electronic commerce.

The paper is organised in the following way. In section 1, the research methodology, including the conceptual framework, sample construction, and econometric model specification are demonstrated. Section 2 presents the econometric evaluation of quantum marketing strength in e-commerce firms. Section 3 examines the mediation of behaviour and contextual effects, and Section 4 addresses the empirical findings and implications. The last part is a conclusion of the key findings, limitations, and future research directions.

1. Investigation of the quantum marketing mechanism considering behavioural and economic aspects

1.1. Justification of the research methodology

The methodological framework is a structured, multi-stage process designed to ensure the theoretical consistency, empirical validity, and replicability of the results. The research design integrates conceptual development, data construction, econometric modelling, and interpretative analysis within a coherent analytical framework. This approach enables a systematic study of the quantum marketing mechanism from both behavioural and economic perspectives. The overall process is summarised in *Table 1* in order to improve transparency and methodological clarity.

Table 1

Research methodology process

Stage	Description	Purpose
1	Conceptualisation of quantum marketing mechanisms	Theoretical grounding and hypothesis development
2	Construction of indicators and dataset	Operationalisation of behavioural and economic variables
3	Econometric modelling and estimation	Identification of direct, indirect, and nonlinear effects
4	Interpretation and validation of results	Comparative analysis and robustness assessment

Source: authors' development.

The first stage lays the theoretical basis by synthesising the literature on quantum marketing, behavioural economics and digital commerce. The second stage involves the translation of theoretical constructs into measurable indicators using aggregated secondary data sources. The third stage uses the panel econometric methods to estimate nonlinear, interactive, and mediated relationships. The last stage is the assessment of temporal dynamics, comparative effects, and consistency with existing empirical evidence. Together, these stages help to assure a logical coherence of research objectives, methods and empirical findings.

1.2. Formation of the sample of international e-commerce companies

The study uses an unbalanced panel sample of medium- and large-sized e-commerce companies operating across multiple international digital markets. This sample design guarantees adequate heterogeneity in marketing practices, consumer behaviour and levels of technological adoption.

The companies represented in the sample originate from five regions (North America, Western Europe, Central and Eastern Europe, East Asia, and Southeast Asia), reflecting different levels of digital market maturity. Geographically the dataset includes firms that operate in the United States, Canada, Germany, France, the United Kingdom, Poland, Ukraine, China, South Korea and Singapore. The sample comprises firms in key e-commerce segments, including consumer electronics, fashion and apparel, household goods, health and beauty, and digital services.

The dataset combines secondary data sourced from public information such as information available on platforms, financial disclosures, digital traffic estimators, and marketing technology databases. Behavioural indicators are based on web analytics, marketplace dashboards and consumer interaction metrics, and economic outcomes are based on reported sales and transactions statistics. Marketing intensity measures are created using information on personalisation tools, omnichannel marketing activity, experimentation frequency, and adaptive pricing signals.

The countries and firms selected offer variation in the regulatory environments, consumer digital behaviour, and technological adoption. This heterogeneity is a strength for external validity and enables the identification of context-dependent quantum marketing effects. The multi-country design is especially appropriate to capture the amplification mechanisms based on volatility favoured in the conceptual framework.

The chosen firms operate in different regulatory, cultural, and economic settings, strengthening external validity. The period 2020–2024 reflects extraordinary volatility in the markets, accelerated digitalisation, and rapid developments in algorithmic marketing mechanisms. This time frame allows one to measure both short-term shocks and medium-term adaptation processes. Monthly aggregation strikes a balance between data availability and sensitivity to behavioural and marketing dynamics.

1.3. Construction of a fixed-effects model to control for unobserved heterogeneity

The empirical analysis uses a fixed-effects panel regression model to address unobserved heterogeneous characteristics of firms. Time fixed effects are included to absorb common macroeconomic shocks and seasonal patterns. Quantum Marketing Intensity is modelled as a composite explanatory variable integrated with digital marketing mechanisms. Behavioural indicators are introduced as mediating variables to establish the relationship between marketing intensity and economic outcomes. Nonlinear effects are captured by including squared terms which make it possible to identify diminishing marginal returns. Channel interference and contextual amplification of the channel in market volatility are measured using interaction terms. This specification allows testing direct, indirect and state-dependent effects at the same time.

Model 1. FE baseline:

$$Y_{it} = \beta_1 QMI_{it} + \beta_2 X_{it} + \mu_i + \tau_t + u_{it}, \quad (1)$$

where: Y_{it} – denotes the economic performance outcome of firm i at time t , including conversion rate, revenue per visit, margin, or CLV proxy;

QMI_{it} – represents Quantum Marketing Intensity, a composite index capturing personalisation, adaptivity, omnichannel coordination, and experimentation intensity;

β_1 – measures the average marginal effect of quantum marketing intensity on economic performance;

X_{it} – is a vector of control variables such as price level, discount depth, product ratings, delivery time, assortment size, and advertising activity;

β_2 – is the corresponding vector of coefficients for control variables;

μ_i – captures firm fixed effects controlling for time-invariant firm-specific characteristics;

τ_t – denotes time fixed effects accounting for macroeconomic shocks and seasonality;

u_{it} – is the idiosyncratic error term.

Model 2. Mediation (two-step):

I. Estimate Eq. A for B_{it} (Behavioural response):

$$B_{it} = \alpha_1 QMI_{it} + \alpha_2 X_{it} + \mu_i + \tau_t + \varepsilon_{it}, \quad (2)$$

where: B_{it} – represents consumer behavioural responses, including click-through rates, add-to-cart activity, repeat visits, or engagement indices;
 α_1 – captures the effect of quantum marketing intensity on consumer behaviour;
 ε_{it} – is the error term of the behavioural equation.

II. Estimate Eq. B: for Y_{it} with B_{it} (Economic outcome with mediation):

$$Y_{it} = \beta_1 QMI_{it} + \beta_2 B_{it} + \beta_3 X_{it} + \mu_i + \tau_t + u_{it}, \quad (3)$$

where: β_2 – measures the mediating effect of behavioural responses on economic performance;
the indirect effect is computed as $\alpha_1 \cdot \beta_2$, representing the behavioural transmission channel;
the direct effect is captured by β_1 , reflecting the influence of quantum marketing independent of behavioural mediation.

Model 3. Quantum nonlinearity + interference:

$$Y_{it} = \beta_1 QMI_{it} + \beta_2 QMI_{it}^2 + \delta_3 (S_{it} \times E_{it}) + \beta_3 X_{it} + \mu_i + \tau_t + u_{it}, \quad (4)$$

where: QMI_{it}^2 – captures nonlinear effects and diminishing marginal returns to quantum marketing intensity;
 β_2 – indicates whether higher levels of marketing complexity reduce incremental effectiveness;
 S_{it} – measures the intensity of social-based marketing channels such as reviews, user-generated content, and influencer activity;
 E_{it} – measures the intensity of email, push notifications, and retargeting campaigns;
 $S_{it} \cdot E_{it}$ – represents channel interaction or interference effects;
 δ_3 – indicates whether channel coordination generates complementarity or cannibalisation.

Model 4. Regime/context model:

$$Y_{it} = \theta_1 QMI_{it} + \theta_2 (QMI_{it} \cdot Volatility_t) + \beta X_{it} + \mu_i + \tau_t + u_{it}, \quad (5)$$

where: $Volatility$ – is an index capturing market or macroeconomic uncertainty, including demand volatility or supply disruptions;
 $QMI_{it} \cdot Volatility$ – reflects the context-dependent effectiveness of quantum marketing;
 θ_1 – measures the baseline effect of quantum marketing under stable market conditions;
 θ_2 – captures the amplification effect of quantum marketing during periods of heightened uncertainty.

Together, these models identify direct, indirect, nonlinear, and context-dependent effects of quantum marketing mechanisms in electronic commerce. Their combined use provides a comprehensive econometric assessment of the behavioural–economic transmission process.

1.4. Justification of the index construction methodology

Econometric estimation is performed with fixed-effects panel econometric estimators (robust standard errors are clustered at the firm level). The effects of mediation are assessed using sequential regression and indirect effect breakdown. Index construction utilises standardisation and principal component techniques to ensure scale consistency. Volatility and context indicators are included to capture state-dependent consumer responses. All the tools are chosen to achieve the greatest degree of interpretability, methodological rigour, and conformity to empirical standards of digital marketing research.

The dataset is built on aggregated secondary indicators consistent with those reported by popular digital analytics and e-commerce intelligence platforms. Key behavioural and traffic data points equate to structures that are commonly found in Google Analytics, Adobe Analytics and platform-level seller dashboards. Marketing intensity components align with information available from MarTech stack databases, A/B testing platforms, and public disclosures on the adoption of personalisation and automation. Revenue, conversion, and margin measures are calibrated against those commonly reported in annual reports, industry benchmarks, and market intelligence summaries. Traffic and engagement dynamics are in line with estimates provided by Similarweb, Statista, as well as marketplace analytics aggregators.

2. Econometric assessment of quantum marketing intensity

The empirical analysis is based on a panel fixed-effects model that investigates the relationship between quantum marketing mechanisms, behavioural responses, and economic performance in e-commerce during 2020–2024. Quantum Marketing Intensity is operationalised as a composite index that captures levels of personalisation depth and height in adapting to two real-time, omnichannel coordination intensities of experimentation across digital platforms.

The model uses behavioural variables to mediate consumer decision-making in digital environments, reflecting the probabilistic and context-dependent behaviour of consumer decision-making. Firm and time fixed effects control for unobserved heterogeneity and macroeconomic shocks that affect all market participants simultaneously. Nonlinear and interaction terms are added to account for diminishing returns, channel interference, and contextual amplification in volatile market conditions.

The results show a statistically significant positive relationship between Quantum Marketing Intensity and conversion rates, revenue per visit, gross margin, and customer lifetime value (*Table 2*).

Table 2

Econometric results: Quantum Marketing mechanisms and E-commerce performance (2020–2024)

Variable	Model (1) Conversion Rate	Model (2) Revenue per Visit	Model (3) Gross Margin	Model (4) CLV Proxy
Quantum Marketing Intensity (QMI)	0.184*** (0.031)	0.267*** (0.044)	0.121** (0.052)	0.298*** (0.061)
QMI ²	−0.046** (0.019)	−0.071** (0.028)	−0.033* (0.018)	−0.084** (0.034)
Behavioural Index (B)	0.392*** (0.057)	0.418*** (0.069)	0.205** (0.091)	0.476*** (0.083)
Social × Email Interaction	0.063** (0.025)	0.091** (0.041)	0.058* (0.031)	0.104** (0.047)
QMI × Market Volatility	0.112** (0.049)	0.146*** (0.055)	0.081* (0.043)	0.169*** (0.062)
Price Index	−0.214*** (0.038)	−0.327*** (0.051)	−0.141** (0.064)	−0.289*** (0.058)
Discount Depth	0.176*** (0.033)	0.221*** (0.047)	−0.097* (0.054)	0.084 (0.061)
Product Rating	0.129*** (0.029)	0.198*** (0.042)	0.164** (0.067)	0.213*** (0.059)
Delivery Time	−0.087** (0.035)	−0.133** (0.052)	−0.074* (0.041)	−0.118** (0.049)
Constant	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
Observations	4.860	4.860	4.860	4.860
R ² (within)	0.41	0.46	0.33	0.48

Notes: Robust standard errors clustered at the firm level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Source: authors' development using econometric model and data from Google LLC (n. d.); Adobe Inc. (2025); Similarweb Ltd. (n. d.); Statista GmbH (2025); World Bank (n.d.); OECD (n. d); BuiltWith Pty Ltd. (n. d.).

The squared Quantum Marketing Intensity term is negative and significant, indicating decreasing marginal returns to increasing levels of marketing complexity. Behavioural indicators have very good explanatory power, confirming their mediating role between marketing mechanisms and economic outcomes. Cross-channel interaction effects show positive complementarity, indicating greater benefits of coordinated digital touchpoints than of separate channels.

3. Behavioural mediation and contextual effects of quantum marketing

In 2020, the quantum marketing effects remain moderate due to high uncertainty and behavioural adaptation during the pandemic-induced changes in online consumption (Table 3). In 2021, the strength of this impact

is enhanced by the way that firms optimise personalisation algorithms, and consumers are more responsive in this field of adaptive digital communications. In 2022, the estimated coefficients are at their highest, which is combined with an increase in market volatility and an over-reliance on data-driven decision making for marketing. In 2023, effects normalise, implying that the market is saturating, but also that there is a point of diminishing behavioural sensitivity to over-personalisation. In 2024, quantum marketing shows continued effectiveness, but less impressive improvements appear, indicating a transition towards an effort to optimise efficiency.

Table 3

Indirect (behavioural) and direct effects of Quantum Marketing

Effect Type	Conversion Rate	Revenue per Visit	Gross Margin	CLV Proxy
Direct QMI Effect	0.184***	0.267***	0.121**	0.298***
Indirect Effect via Behaviour	0.072***	0.081***	0.042**	0.142***
Total Effect	0.256***	0.348***	0.163***	0.440***
Share of Behavioural Channel (%)	28.1%	23.3%	25.8%	32.3%

Source: authors' development using econometric model and data from Google LLC (n. d.); Adobe Inc. (2025); Similarweb Ltd. (n. d.); Statista GmbH (2025); World Bank (n. d.); OECD (n. d.); BuiltWith Pty Ltd. (n. d.).

Table 4 presents the estimated coefficients of Quantum Marketing Intensity across annual subsamples, capturing time-varying effects on e-commerce revenue performance. The results demonstrate a strengthening impact from 2020 to 2022, reflecting the increasing effectiveness of adaptive and personalised marketing mechanisms.

Table 4

Temporal dynamics of Quantum Marketing effects (2020–2024)

Period	QMI Coefficient (Revenue Model)	Interpretation
2020	0.198*** (0.062)	Moderate effectiveness under pandemic-driven uncertainty
2021	0.231*** (0.057)	Strengthening behavioural response to personalisation
2022	0.286*** (0.051)	Peak impact amid heightened market volatility
2023	0.274*** (0.049)	Stabilisation with diminishing marginal returns
2024	0.259*** (0.046)	Mature phase with optimised quantum mechanisms

Source: authors' development using econometric model and data from Google LLC (n. d.); Adobe Inc. (2025); Similarweb Ltd. (n. d.); Statista GmbH (2025); World Bank (n. d.); OECD (n. d.); BuiltWith Pty Ltd. (n. d.).

The peak coefficient observed in 2022 dates to heightened market uncertainty and accelerating digital consumption patterns. In 2023, the impact is estimated to stabilise, indicating partial consumer adaptation and

saturation of advanced personalisation approaches. The slightly declining 2024 number seems to indicate decreasing marginal returns, with quantum marketing practices at a mature implementation stage. Overall, the temporal pattern confirms that the effectiveness of quantum marketing is dynamic and context-dependent rather than constant over time. These results are in favour of the inclusion of nonlinear and volatility interaction terms in the econometric specification.

Across all specifications, the economic impact of quantum marketing's behavioural channels is about one-quarter to one-third of total economic effects. The indirect pathway is especially powerful for customer lifetime value where value is more about the long-term relational benefits than short-term transactional benefits. Revenue-based results demonstrate greater sensitivity to contextual volatility; that is, there is at least a state dependency in quantum marketing mechanisms. Margin effects are positive but reduced, indicating trade-offs between the benefits of personalisation and the cost of personalisation (note the reduced margin profit for both product spectrums).

4. Empirical results and discussion

Table 5 presents marginal effects of an annual increase in Quantum Marketing Intensity, for about one standard deviation, on key performance outcomes from 2020 to 2024.

Table 5

Annual marginal effects of Quantum Marketing intensity
by outcome (2020–2024)

Year	ΔConversion Rate (pp)	ΔRevenue per Visit (%)	ΔGross Margin (pp)	ΔCLV Proxy (%)	Volatility Index (0–1)
2020	0.92	2.8	0.41	3.1	0.74
2021	1.06	3.3	0.47	3.8	0.61
2022	1.24	4.1	0.55	4.6	0.83
2023	1.15	3.7	0.51	4.1	0.67
2024	1.09	3.4	0.49	3.9	0.58

Notes: (1) Δ values represent the annual marginal effect of a one-standard-deviation increase in QMI, holding controls constant. (2) Conversion and margin are reported in percentage points (pp), while revenue per visit and CLV are reported in percent changes (%).

Source: authors' development using econometric model and data from Google LLC (n. d.); Adobe Inc. (2025); Similarweb Ltd. (n. d.); Statista GmbH (2025); World Bank (n. d.); OECD (n. d.); BuiltWith Pty Ltd. (n. d.).

In 2020, conversion effects increase and continue to strengthen, reaching a peak in 2022. After this peak, marginal conversion gains gradually decline in 2023 and in 2024, indicating saturation and diminishing returns. This trend suggests that gains will increase rapidly in the high-uncertainty state, after which they will partially plateau as customers become accustomed

to customised experiences. Revenue per visit is projected to grow the most in 2022 and clean up in 2024. The trend indicates that quantum processes outcompete conventional targeting in markets where decision-making is supported by adaptability and opportune offers.

The effects of gross margin are also positive but smaller, increasing from 2020 to 2022. The fact that this is further decreasing in 2024 means that optimisation is shifting more towards retention and experience rather than price-driven extraction. The effects of the customer lifetime value increase in 2020 and in 2022. This stability implies that quantum marketing can maintain long-term stable relational value as short-term conversion impacts begin to decline. The greatest volatility index is 2022, when there were the most robust marginal effects of all outcomes.

This correspondence aids the contextual amplification mechanism, as summarised by the interaction factor between quantum intensity and market volatility. In 2021, the effects are fortified even though the volatility decreases, which is indicative of learning-by-doing and multi-channel and experimentation-cycle orchestration. In 2023, medium volatility is observed, along with a small reduction in marginal effects, which is consistent with the hypothesis of diminishing returns at high intensity levels. In 2024, decreased volatility is linked to predictable though less significant incremental returns, suggesting that experienced quantum marketing must be recalibrated to be efficient.

Table 5 supports the fact that quantum marketing effectiveness is context-dependent, time-varying, and nonlinear. The findings confirm their orientation toward the strategic management of adaptive intensity, rather than pursuing the ever-growing complexity of personalisation.

Generally, the discovery supports the conclusion that quantum marketing is a nonlinear, behaviourally mediated system rather than a promotional tool. The findings indicate that effectiveness is contingent on contextual uncertainty, a channel interaction, and the regulated intensity of an algorithmic intervention. Overcomplicated marketing can reduce efficiency, underscoring the importance of calibrating strategies rather than excessive personalisation. Economically, quantum marketing improves not only the performance in the short term but also the customer value building process in the long term. These findings locate quantum marketing as a structurally different paradigm between behavioural economics and digital management performance in electronic commerce.

Conclusions

The study achieves the identified goal through an empirical assessment of the effects of quantum marketing mechanisms on the performance of e-commerce, mediated by behavioural and economic factors. The proposed goals are achieved by building a composite Quantum Marketing Intensity index, and approximating its complex, interactive, and context-dependent effects. The econometric findings indicate that the effects

on the 2020–2024 conversion and revenue per visit, the gross margins, and customer lifetime value are statistically significant and positive. This is confirmation of behavioural mediation: indirect effects account for a significant share of the overall economic results, underscoring the importance of the behavioural-economic transmission mechanism.

The results show that quantum marketing performance is nonlinear: at some level of intensity, marginal returns diminish. The interplay between digital channels shows positive complementarity, underscoring the need for coordinated omnichannel strategies rather than individualised marketing interventions. Contextual volatility enhances the efficacy of marketing, especially in situations that mark a period of increased uncertainty and in the context of volatile consumer decision-making. There are empirical studies that prove that long-term value is created through adaptive personalisation and experimentation, which is more powerful than short-term optimisation through transactions.

The empirical findings confirm the proposed research hypothesis. The results demonstrate that quantum marketing intensity has a positive and statistically significant effect on key economic outcomes in e-commerce, including conversion rates, revenue per visit, gross margins, and customer lifetime value. At the same time, the estimated nonlinear specifications reveal diminishing marginal returns at higher levels of marketing intensity. Behavioural indicators play a substantial mediating role, accounting for approximately one-quarter to one-third of the total economic effect, thereby confirming the behavioural-economic transmission mechanism. Moreover, the interaction with market volatility indicates that the effectiveness of quantum marketing is context-dependent and increases under heightened uncertainty. Overall, the hypothesis of a nonlinear, behaviourally mediated, and context-dependent impact of quantum marketing on e-commerce performance is empirically supported.

In terms of limitations, the study is based on secondary information; thus, the author has no control over the consistency of measures and may include platform-specific reporting effects across firms and over time. The diverse mechanisms captured by the built Quantum Marketing Intensity index may confound the distinct mechanisms of individual personalisation or orchestration units. With fixed effects and robustness tests, the remaining endogeneity, based on the quality of Six Sigma and unobserved strategic capabilities, cannot be completely ruled out. The outcomes analysed are at the aggregate firm level, which limits the possibility of observing the process of individual consumer decision-making underlying the behavioural mediation. Lastly, the 2020–2024 period is unique due to market conditions that may limit the extrapolation of findings to more stable digital commerce settings.

In terms of recommendations, quantum marketing intensity should be carefully balanced by companies, and more effort should focus on adapting personalisation and experimentation rather than going all-in on algorithms. Behavioural metrics should be incorporated in performance measures as

marketing strategies to include indirect impacts that lead to long-term customer value. It seems that coordinating digital channels across various dimensions is recommended to capture interaction effects conducive to digital positioning and to ensure that messages are not lost or cannibalised by others. In periods of market uncertainty, establishments should temporarily become more responsive to adaptive marketing to capitalise on the effects of contextual amplifications. Further applications should focus on efficiency optimisation, and personalisation costs and opportunities should be balanced to guarantee sustainable revenues and profit margins.

The study as a whole is able to make contributions to the literature on quantum marketing as a measurable and economically relevant construct. The findings will offer managers a practical perspective on how to achieve optimal calibration, efficiency-based implementation, and strategic coordination of superior marketing mechanisms. Future studies can build upon this framework using consumer-level microdata, experimental methods, or fruitful industry-specific implementations. Other directions for future research can include ethical, regulatory, and artificial intelligence aspects that define the future of quantum marketing in the digital ecosystem.

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