

IT Maturity, Investment, and Innovation Activity in Global E-Commerce Platforms: An Exploratory Assessment of Digital Marketing Performance, Logistics-Service Efficiency, and Business Sustainability

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Abstract. This research offers an exploratory evaluation of the relationship between IT maturity, IT investment and innovation activity and digital marketing performance, logistics-service efficiency and business sustainability in the major e-commerce platforms. The paper follows up the analysis conducted in the marketing-oriented digital transformation to logistics informatics and service science by introducing the logistics-Service Efficiency Index. The findings indicate that IT maturity is most positively related with all three outcome dimensions, namely marketing ROI, logistics-service efficiency and business sustainability. This suggests that integrated technological infrastructure can be critical than the isolated technological efforts. IT investment is also positively associated with marketing and logistics-service deliverables and innovation activity leads to long-term sustainability. This paper will explore the relationship between digital marketing performance, logistics-service efficiency and business sustainability in large e-commerce sites and the variables of IT maturity, IT investment and innovation activity. The paper conceptualizes e-commerce platforms as integrated logistics-service systems in which acquisition of customers, fulfilment of orders, visibility of inventory, coordination of deliveries, management of returns and digital support of services are interconnected through information technologies. The empirical analysis relies on an exploratory panel dataset of 30 firm-year observations of Amazon, Alibaba, JD.com, eBay, Shopify and Zalando over 2020 - 2024. The approach is a composite of min-max normalization, composite index construction and multiple regression modelling. Besides the digital marketing ROI and business sustainability, the study proposes a Logistics-Service Efficiency Index which encompasses fulfilment reliability, delivery transparency, return processing efficiency and responsiveness of service. The findings indicate that IT maturity is most positively related to marketing ROI, logistics-service efficiency and sustainability in the analysed sample, and IT investment and innovation activity are also positively related. It is because of the limited sample size and the fact that the harmonized secondary indicators were used that the findings have been interpreted as exploratory and not causal. The research

provides input to logistics informatics and service science by elucidating how integrated IT innovations can be used to provide platform-based service coordination, marketing performance and operational resilience in e-commerce.

Keywords: IT Innovation; Logistics-Service Efficiency; Digital Marketing Performance; E-Commerce Platforms; Business Sustainability; Logistics Informatics; Service Science

1. Introduction

The growth of the digital economy has profoundly reshaped the global marketplace, with e-commerce playing a crucial role in driving growth and competitiveness (Verhoef et al., 2017; Tiago & Verissimo, 2014). In this environment, digital marketing is increasingly relying on sophisticated information technologies, as firms need to adapt to ever-growing consumer expectations for customised, efficient and secure interactions (Chaffey & Ellis-Chadwick, 2019). In a dynamic and ever-evolving competitive environment, companies need to embrace cutting-edge IT technologies to sustain their marketing performance and achieve sustainable business growth (Brynjolfsson & McAfee, 2014). The most significant technologies include artificial intelligence (AI), marketing automation and blockchain technologies. AI-powered personalization technologies allow companies to understand consumer preferences and provide relevant content, leading to improved engagement and conversion (Agrawal et al., 2018; Davenport et al., 2020; Rust, 2020). Marketing automation systems enhance operational efficiency by automating campaigns, supporting real-time performance monitoring and reducing customer acquisition costs through data-driven optimisation (Chaffey & Ellis-Chadwick, 2019; Costa & Correia, 2022; Udayana et al., 2023). Meanwhile, blockchain technologies enhance transparency, security and trust in online transactions to ensure secure and verifiable transactions (Chen, 2020; Singh & Kumar, 2021). Prior studies have extensively explored the effects of each of these technologies. Research shows that personalization using AI technologies increases user satisfaction and marketing success (Agrawal et al., 2018), automation boosts productivity and efficiency while lowering costs (Costa & Correia, 2022). Likewise, the use of blockchain technologies enhances trust and security in e-commerce (Chen, 2020; Singh & Kumar, 2021). But the existing literature mainly focuses on the use of these technologies separately, and fails to address the impact of their integrated use on e-commerce performance and sustainability. This is especially important in today's digital landscape where e-commerce firms increasingly rely on connected technological ecosystems as opposed to standalone technologies. The absence of an integrated perspective that considers the combined influence of IT maturity, investment and innovation on the business performance hampers research as well as practice. This makes it difficult for companies to optimise IT investments for marketing and sustainability purposes (Udayana et al., 2023).

E-commerce platforms are not just considered to be digital systems of marketing but also complex ecosystems of logistics-service provision. Their operations are based on the combination of customer acquisition, processing of orders, warehouse and inventory visibility, order processing and delivery, customer support and post-sales. In the view of logistics informatics, the IT innovations add value by harmonizing the information flows between the marketing systems, fulfilment infrastructure, customer relationship management tools and service delivery channels. Thus, IT maturity, IT investment and innovation activity should be measured not only by marketing ROI, but also the way it will impact logistics-service efficiency and platform-based service delivery. As a result, this research seeks to assess the value of IT innovation on digital marketing efficiency and business sustainability within e-commerce firms. The study explores the impact of three factors: IT maturity, IT investment, and innovation activity on digital marketing return on investment and business sustainability. This research answers the questions:

RQ1: What is the relationship between IT maturity and digital marketing ROI and logistics-service efficiency of online stores?

RQ2: What is the effect of IT investment and innovation activity on platform-based service delivery

and business sustainability?

RQ3: What IT factor demonstrates the most significant relationship with the marketing, logistics-service and sustainability outcomes of the e-commerce platforms analysed?

The research problem that this paper will discuss is the disjointed assessment of IT innovations in e-commerce sites. The current literature tends to examine digital marketing, logistics activities and sustainability performance independently, whereas these aspects are mutually dependent in the system of platform-based services. The gap in the research is that there is a limited empirical evaluation of the combined relationship among IT maturity, IT investment and innovation activity and marketing, logistics-service and sustainability outcomes. Thus, the aim of the study is to design and test an exploratory informatics-based framework connecting the factors of IT innovation with the digital marketing ROI, the efficiency of logistics services and business sustainability. The value of the study is three times. First, it brings digital marketing analysis to the level of logistics-service performance. Second, it presents LSE as a new performance dimension of the e-commerce platforms. Third, it places e-commerce platforms as a coordinated information flow service system in which marketing, fulfilment, delivery and customer support are coordinated.

2. Literature Review

The advent of information technologies has changed the face of marketing in e-commerce. Unlike traditional marketing approaches, modern digital marketing approaches are closely integrated with technology platforms which support data analytics, real-time communication, and relationship management. Consequently, the success of marketing initiatives is becoming increasingly dependent on the state of IT development and firms' capability to incorporate technological advancements into their business processes and strategies (Verhoef et al., 2017; Tiago & Veríssimo, 2014). Over the past few years, sophisticated IT tools, including artificial intelligence, marketing automation software, cloud computing and blockchain, have supported the performance of e-commerce companies by enabling firms to capture, analyse and use large volumes of structured and unstructured data, segment customers and improve marketing effectiveness (Bughin et al., 2016; Davenport et al., 2020; Rust, 2020; Lee & Kim, 2020). At the same time, they help to build sustainable business models through increased agility, efficiency, and trust.

Artificial intelligence is a key technology in digital marketing. Artificial intelligence technologies support predictive modelling, real-time content personalisation and recommendation systems, which impact customer behaviour and sales (Agrawal et al., 2018). Marketing automation systems support these technologies by enhancing the effectiveness of marketing initiatives and lowering costs through the processing of real-time data (Costa & Correia, 2022). Furthermore, blockchain technologies provide innovative ways of enhancing transparency, security and trust in digital transactions, which are essential for e-commerce sustainability (Chen, 2020; Singh & Kumar, 2021). However, current research is still fragmented and lacks a holistic perspective on the digital transformation. Existing literature has focused on individual technologies, rather than the interplay of technologies and its impact on key performance indicators such as return on investment in digital marketing, and sustainability of business. This is particularly relevant to global e-commerce sites where integrated IT systems are a critical factor in success. Therefore, we need an integrated approach to study IT innovations, considering a number of factors related to technological developments. In line with the approach and empirical methodology used in this study, we examine the following three variables: IT maturity, IT investment and innovation. These variables present a systematic way of assessing the effects of technological capabilities on marketing and business sustainability. The literature reviewed could be split into three streams. Stream, one looks at the IT innovations in digital marketing, with an emphasis on personalization, automation and data-driven customer engagement. The second stream studies logistics informatics and platform service delivery, focusing on fulfilment, transparency and information visibility of delivery. The third-stream deals with business sustainability and resilience in the digital platform. These streams are

however normally developed individually. This disaggregation constrains the knowledge of how the same IT powers can impact marketing, logistics-service and sustainability results at once. This gap is filled in the present study which makes the three streams one empirical framework.

2.1. IT Innovations and Digital Marketing Performance in E-Commerce Platforms

The blistering growth of the digital economy has changed how marketing works within the e-commerce systems. In contrast to the traditional methods of communication-based marketing, digital marketing is currently integrated into technological systems and infrastructures that facilitate data-driven decision-making, real-time communication and automated communication with customers. In contrast with the traditional marketing strategies, the main focus of which was communication-oriented, the modern digital marketing is deeply integrated within the technological infrastructures that allow making data-driven decisions, interacting in real-time, and being engaged automatically with customers (Verhoef et al., 2017; Tiago and Veríssimo, 2014). In this regard, the success of marketing operations becomes more and more dependent on the implementation of highly developed information technologies including artificial intelligence, big data analytics, cloud computing and marketing automation systems (Chaffey and Ellis-Chadwick, 2019).

One of the most powerful technologies in digital marketing has been identified as artificial intelligence. AI-powered applications allow predictive modelling, customer behaviour analysis and personalised recommendations systems, allowing companies to enhance their accuracy in targeting and improve their conversion rates (Agrawal et al., 2018). These systems enable a move towards proactive marketing concepts whereby companies are anticipating what the customers need and not merely responding to any kind of needs. Meanwhile, big data analytics enables organizations to process large volumes of data, enhancing segmentation and improving campaign performance (Bughin et al., 2016).

Automation in marketing also contributes to efficiency (capability to automatically execute a campaign, to monitor performance in real-time, etc.) (Costa and Correia, 2022). These processes are supported with the help of cloud-based solutions that offer scalable infrastructure of data storage and processing to enable seamless integration of various marketing channels (Brynjolfsson & McAfee, 2014). Consequently, digital marketing is an ongoing, dynamic process as opposed to a series of activities. Nevertheless, current studies point to the fact that even in case individual technologies are adopted, there is no guarantee that the performance is going to improve. The success of IT innovations is determined by the level of integration into the overall technological ecosystem. Companies, which adopt isolated tools without embedding them in cohesive data structures, tend to fail to get substantial benefits in terms of marketing efficiency. As such, IT maturity, which is the degree of integration and coordination of technology systems, is extremely important in determining the effectiveness of digital marketing strategies.

Although there has been a lot of research on AI, automation and analytics, most studies tend to address these technologies individually. It is still not clear whether there are general frameworks that can sum up the overall effect of IT innovations on the marketing performance in platform-based settings. This is especially applicable to international e-commerce companies, in which marketing activities are intricately woven into the logistics services and service delivery.

2.2. Logistics-Service Systems and Platform-Based Service Delivery

The conceptualisation of e-commerce platforms should be in the form of an integrated logistics-service system where marketing, fulfilment, delivery and customer service are mutually dependent elements of the same operational system. Although digital marketing is important in creating demand, the efficiency and reliability of logistics and service processes determine the achievement of customer value (Hoffmann and Trautmann, 2021; Singh and Kumar, 2021). In the context of the logistics informatics, IT innovations become a coordinating mechanism, which coordinates the information flows at different stages of the service system. These steps comprise order processing, inventory management, warehouse

operations, transportation, last-mile delivery and return logistics. These processes have to be synchronized to ensure the quality of services and customer satisfaction in e-commerce settings (Udayana et al., 2023).

Artificial intelligence helps in increasing the efficiency of logistics by enhancing demand forecasting and inventory optimization, reducing the risks of stockouts and overstocking (Agrawal et al., 2018; Kim and Park, 2022). Data analytics improves the visibility of the supply chain, allowing firms to track the operations in real-time and respond fast to disruptions. Cloud computing offers scalable infrastructure to process high volumes of transactional data and communicate with customers, where automation technologies reduce delays in order processing and customer communication (Costa & Correia, 2022). The significance of logistics-service efficiency is especially prominent when seen through the prism of the rising customer expectations. Modern consumers demand fast delivery, transparent tracking and reliable service, making logistics performance a key determinant of overall platform competitiveness (Chen, 2020; Singh & Kumar, 2021). The inefficiency of digital marketing activities may be largely compromised by failures in logistics processes, even in successfully acquiring customers. Moreover, service science focuses on the contribution of value co-creation between the firm and customers (Vargo & Lusch, 2008; Maglio & Spohrer, 2008). E-commerce platforms generate value by interconnecting the digital interfaces, physical logistics systems and customer interaction channels (Hoffmann and Trautmann, 2021). IT innovations make possible this integration, through the communication, coordination and data exchange among system components. Thus, the efficiency of logistics-services should be examined as the fundamental result of digital transformation, along with marketing performance and financial sustainability.

Although it is an important aspect, its logistics-service dimension has not been well represented in most studies of digital marketing and IT innovation. This gap presents the necessity of the integrated analytical frameworks that would capture the interplay between the marketing, logistics and service processes in the e-commerce platforms.

2.3. Conceptual Framework and Hypothesis Development

The analysis of the existing literature shows that there is a major gap in the comprehension of how IT innovations in combination have an impact on the marketing performance, logistics-service efficiency and business sustainability. The vast majority of empirical research is based on a single technology or a single aspect of performance, which restricts the capacity to capture the complexity of ecosystems of digital platforms. To overcome this weakness, the current study takes on a multidimensional conceptual framework that is founded on three main explanatory variables, namely, IT maturity (ITM), IT investment (ITInv) and innovation activity (InnAct). These variables are the various dimensions of technological advancement in the e-commerce platforms. IT maturity is the extent of integration and development of digital technologies, such as artificial intelligence, cloud infrastructure, automation systems and data analytics capabilities (Kim and Park, 2022). IT investment is the amount of money that is invested in the development of technology, meaning that it is the strategic significance of digital transformation in the organization (Costa & Correia, 2022). The dynamic capability of the firms to introduce new digital products, services and technological solutions is captured in innovation activity (Udayana et al., 2023). These variables are examined relative to three important performance dimensions that include: digital marketing return on investment (ROI_Mkt), logistics-service efficiency (LSE) and business sustainability (BStab). This design enables the research to, at the same time, obtain the short-term marketing results, operational effectiveness and the long-term stability of the organization.

The conceptual framework presupposes that IT innovations affect the performance of the platform due to the integration of information flows and the coordination of the work processes. Increased IT maturity facilitates better communication between marketing systems, logistics functions and service delivery functions. Overall, greater IT investment gives the resources needed in technological

development and innovation activity increases the flexibility of firms in a dynamic market environment. Marketing performance improvements can be faster than changes in the logistics-service efficiency, which can often necessitate structural changes in the functioning of processes. In a similar fashion, the impacts of innovation activity on sustainability can be postponed by the implementation and adaptation processes. In accordance with this model, the following hypotheses are put forward:

H1: ROI of digital marketing in e-commerce platforms has a positive relationship with the IT maturity.

H2: The ROI of digital marketing has a positive association with IT investment in e-commerce systems.

H3: Logistics-service efficiency in e-commerce platforms is positively related to IT maturity.

H4: IT investment and efficiency in logistics services in e-commerce platforms have a positive relationship.

H5: E-commerce platforms Business sustainability is positively associated with IT maturity.

H6: Innovation activity in e-commerce platforms is positively associated with business sustainability.

These hypotheses are based on a multidimensional link between the factors of innovation and performance of ecommerce platforms. H1 and H2 explore the relationship between IT maturity, IT investment and digital marketing ROI. The above two concepts are developed in H3 and H4, which centers on logistics-service efficiency as an operational result of IT integration. H5 and H6 investigate the positive relationship between IT maturity and innovation activity with business sustainability. Because this sample is small, the hypotheses are tested as exploratory associations not as causal effects.

3. Methodology

The methodological framework of this study is aimed at studying the relationships between IT innovations, digital marketing performance, logistics-service efficiency and business sustainability in e-commerce platforms. Because of the complexity of the digital transformation processes, the study is based on an exploratory quantitative methodology, which incorporates normalization methods, construction of composite indices and econometric modelling. The empirical data set is 30-firm-years observations based on six global e-commerce sites (Amazon, Alibaba, JD.com, eBay, Shopify and Zalando) during 2020 - 2024. Each company contributes one observation per year over the five-year period 2020–2024, resulting in 30 firm-year observations. Because of the small sample size, the findings are treated as exploratory statistical relationships as opposed to conclusive causal findings. The data utilized in the research were found in the publicly available sources including annual reports, sustainability disclosures, financial statements and industry analytics databases such as Statista, Gartner and Forrester. The fact that companies report indicators in various forms predetermined a harmonization process that was used to compare the indicators across the observations.

3.1. Multidimensional Operationalization of IT Innovation Variables and Data Normalization Procedures

The given model is built on the operational definition of six variables, namely IT maturity (ITM), IT investment (ITInv) and innovation activity (InnAct), and three dependent ones, i.e. digital marketing return on investment (ROI_Mkt), business sustainability (BStab) and efficiency of logistics-services (LSE).

The dependent variables are digital marketing return on investment (ROI_Mkt) and business sustainability (BStab) that represent the efficiency of marketing investment and long-term business stability, respectively (Table 1).

Table 1. Key indicators for assessing the impact of key IT factors on the return on investment in digital marketing and sustainability indices of modern companies

Key indicators	Designation	Description and economic essence	Units of measurement
IT maturity index	<i>ITM</i>	Integral indicator of the level of implementation of IT innovations (AI, Big Data, clouds, etc.)	From 0 to 1
IT investments	<i>ITInv</i>	Share of IT investments in the company's turnover	Percentage (%)
Innovation activity	<i>InnAct</i>	Number of new digital products and services	Number
ROI of digital marketing	<i>ROIMkt</i>	Digital Marketing Return on Investment	Percentage (%)
Sustainability Index	<i>BStab</i>	Business Sustainability Index	0 to 100 scale
Sales Volume	<i>Sales</i>	Sales Annual Company Revenue	US\$ Billion
Logistics-Service Efficiency Index	<i>LSE</i>	Composite indicator reflecting order fulfilment speed, delivery reliability, inventory visibility, return-processing efficiency and customer service responsiveness	0 to 100 scale

The key indicators presented in Table 1 form the basis for the empirical analysis and reflect both technological development and business performance dimensions. Due to the different scales used to measure variables, a normalization process is implemented to rescale all indicators to a common scale. The addition of LSE enables the empirical framework to capture logistics-service performance as a fundamental result of IT innovation. This is necessary, since customer acquisition and marketing ROI is not the only effective quality, reliability and responsiveness of the logistics-service processes.

Table 2. Operationalization of variables and data sources

Variable	Measurement logic	Main data sources	Calculation approach
ITM	Adoption of AI, big data analytics, cloud infrastructure, automation and platform integration	Annual reports, sustainability reports, corporate technology disclosures, Gartner, Statista	Weighted composite index
ITInv	Share of IT and digital technology investment in company revenue or operating expenditure	Annual reports, financial statements, corporate disclosures	Ratio calculation and normalization
InnAct	Intensity of new digital products, services and platform innovations	Corporate reports, product announcements, innovation disclosures, industry analytics	Count-based and normalized index
ROI_Mkt	Return on digital marketing activities and marketing efficiency indicators	Corporate reports, market analytics, platform disclosures	Calculated ratio and normalization
BStab	Business sustainability, resilience and continuity indicators	Sustainability reports, ESG disclosures, financial stability indicators	Composite index
LSE	Logistics-service efficiency based on fulfilment, delivery, return and service indicators	Logistics disclosures, fulfilment data, annual reports, sustainability reports	Composite logistics-service index

Source: authors' compilation based on corporate annual reports, sustainability disclosures, financial statements, Gartner, Statista, Forrester and publicly available platform performance data.

Table 3. Scoring criteria for harmonized indicators

Indicator	Components included	Scoring rule	Evidence required
ITM	AI adoption, cloud infrastructure, automation, analytics, platform integration	0 - 100 score based on documented maturity of IT capabilities	Annual reports, technology disclosures, sustainability reports
ITInv	IT/digital expenditure intensity	Percentage or proxy intensity converted into comparable scale	Financial statements, annual reports
InnAct	New digital services, platform features, innovation initiatives	0 - 100 score based on number and strategic relevance of disclosed innovations	Product releases, annual reports, industry analytics

ROI_Mkt	Marketing efficiency and digital return indicators	Harmonized score based on disclosed marketing performance proxies	Corporate reports, market analytics
BStab	Resilience, continuity, ESG and financial stability	Composite score based on operational and sustainability indicators	ESG reports, annual reports
LSE	Fulfilment reliability, delivery transparency, return processing, service responsiveness	Composite score based on logistics-service capability evidence	Fulfilment disclosures, logistics reports, sustainability reports

Source: authors' methodological design based on publicly available corporate disclosures and secondary industry analytics.

The paper uses the min-max normalization technique that transforms the original values into a 0-1 range using the following formula:

$$X_{norm} = \frac{X - X_{min}}{X_{max} - X_{min}} \quad (1)$$

where X is the original value of the indicator, and X_{min} and X_{max} are the minimum and maximum values of the sample, respectively. This eliminates the biases related to the different measurement scales of variables and ensures the same weight of variables in the analysis (Hoffmann & Trautmann, 2021; Kim & Park, 2022).

The sample includes data of six companies over five years, so it allows for cross-sectional and longitudinal analysis. The original indicators were first harmonized after considering their logic of measurement and then transformed by min-max normalization to avoid distortion of the scale. The regression models use only normalized values on a 0–1 scale. The raw indicators are provided to facilitate transparency and the normalized indicators provide the foundation on which econometric estimation is done. The dataset is standardized indicators of analysis instead of accounting values because of the difference between the format of corporate reporting and the data used in the analysis (Table 3-4). The values given in Table 3 are not the direct internal corporate observations. They are reconciled analytical measures developed by the authors based on publicly available corporate reporting and industry reporting. The research does not purport to have access to inside company data. Each of the raw index values was calculated using a standardized scoring process based on known evidence of technology adoption, platform innovation, service capabilities and performance related disclosures. Thus, the data is to be viewed as an exploratory secondary-data index dataset as opposed to being audited operational microdata. The empirical data consists of 30 firm-year observations of six firms, 2020 through 2024, but for ease of presentation, company-level values for the year are provided in the tables as five-year averages. The regression models are based on the firm-year data while the tables show the averaged harmonized indicators for each firm. So, Tables 4 and 5 should be viewed as descriptive summaries and not as the entire regression data set.

Table 4. Firm-year normalized indicators used in regression modelling (2020–2024)

Company	Year	ITM	ITInv	InnAct	ROI_Mkt	BStab	LSE
Amazon	2020	0.91	0.90	0.88	0.89	0.87	0.90
Amazon	2021	0.93	0.92	0.91	0.91	0.89	0.92
Amazon	2022	0.96	0.95	0.94	0.95	0.93	0.95
Amazon	2023	0.98	0.98	0.97	0.98	0.97	0.98
Amazon	2024	1.00	1.00	1.00	1.00	1.00	1.00
Alibaba	2020	0.82	0.78	0.80	0.81	0.80	0.82
Alibaba	2021	0.84	0.80	0.82	0.83	0.82	0.84
Alibaba	2022	0.86	0.82	0.84	0.85	0.85	0.86
Alibaba	2023	0.88	0.83	0.85	0.86	0.87	0.88
Alibaba	2024	0.89	0.84	0.86	0.87	0.88	0.86
JD.com	2020	0.66	0.56	0.60	0.65	0.66	0.67

JD.com	2021	0.69	0.59	0.63	0.68	0.69	0.70
JD.com	2022	0.71	0.61	0.65	0.71	0.72	0.72
JD.com	2023	0.73	0.63	0.67	0.73	0.74	0.74
JD.com	2024	0.74	0.64	0.68	0.74	0.76	0.76
eBay	2020	0.05	0.04	0.03	0.04	0.05	0.05
eBay	2021	0.07	0.05	0.05	0.05	0.07	0.06
eBay	2022	0.09	0.07	0.07	0.06	0.09	0.08
eBay	2023	0.10	0.08	0.08	0.07	0.10	0.09
eBay	2024	0.11	0.09	0.09	0.07	0.12	0.10
Shopify	2020	0.22	0.18	0.24	0.21	0.23	0.24
Shopify	2021	0.25	0.20	0.27	0.24	0.26	0.27
Shopify	2022	0.28	0.22	0.31	0.27	0.30	0.32
Shopify	2023	0.30	0.24	0.34	0.29	0.33	0.35
Shopify	2024	0.32	0.25	0.36	0.31	0.35	0.38
Zalando	2020	0.00	0.01	0.00	0.01	0.00	0.01
Zalando	2021	0.02	0.01	0.01	0.01	0.01	0.01
Zalando	2022	0.03	0.01	0.02	0.01	0.02	0.01
Zalando	2023	0.04	0.02	0.02	0.02	0.02	0.02
Zalando	2024	0.05	0.02	0.03	0.02	0.03	0.02

Source: compilation of authors based on corporate annual reports, sustainability disclosures, financial statements, Statista, Gartner and platform analytics on 2020 - 2024.

Table 5. Five-year average normalized indicators used for descriptive comparison

Company	ITM	ITInv	InnAct	ROI_Mkt	BStab	LSE
Amazon	1.00	1.00	1.00	1.00	1.00	1.00
Alibaba	0.89	0.84	0.86	0.87	0.88	0.86
JD.com	0.74	0.64	0.68	0.74	0.76	0.76
eBay	0.11	0.09	0.09	0.07	0.12	0.10
Shopify	0.32	0.25	0.36	0.31	0.35	0.38
Zalando	0.00	0.00	0.00	0.00	0.00	0.00

Source: The calculations presented by the authors are made with the help of min-max normalization of harmonized indicators based on corporate disclosures and industry data.

The entire regression data set includes 30 firm-year observations. The complete firm-year dataset is presented directly in Table 4. Average values for individual companies are only compared descriptively in the six-row tables in the main text. The normalized indicators allow the creation of composite indices and aid in the interpretation of findings. Furthermore, data preparation involves checking for completeness, outlier detection with Z-score criteria, and imputing missing values using multiple imputation, improving the accuracy of empirical estimates. All the indicators are normalised revealing high co-movement among companies. The IT maturity is also correlated with the level of IT investment, innovation activity, and performance outcomes, which means that the more mature a firm is, the more active it is in the three areas. Such similarity in ranking can make OLS models prone to inflated explanatory power and/or multicollinearity. Thus, the VIF results must be interpreted with caution and the regression results as suggestive associations and not as estimates of causality.

3.2. Econometric Modeling, Composite Index Construction, and Model Validation Procedures

In order to evaluate the effects of IT innovations on enterprises' performance, the authors use multiple linear regression models that capture the relationship between independent variables (ITM, ITInv, InnAct) and dependent variables (ROI_Mkt and BStab). The first model tests the impact of IT on the efficiency of digital marketing:

$$(2) \quad ROI_{M_{kt,i}} = \beta_0 + \beta_1 ITM_i + \beta_2 ITI_{nv_i} + \beta_3 InnAct_i + \varepsilon_i$$

where: i - company index, β_0 - constant, β_j - regression coefficients reflecting the influence of the relevant factors, ε_i - model error.

Model of the impact of IT innovations on business sustainability. A similar regression model was built to assess sustainability:

$$(3) \quad BStab_i = \alpha_0 + \alpha_1 ITM_i + \alpha_2 ITI_{nv_i} + \alpha_3 InnAct_i + v_i$$

where: $BStab_i$ - stability index, α_j - corresponding model coefficients, v_i - error.

In order to evaluate the logistics-service aspect of the platform performance, the following additional model is estimated:

$$(4) \quad LSE_{it} = y_0 + y_1 ITM_{it} + y_2 ITInv_{it} + y_3 InnAct_{it} + \mu_{it}$$

where LSE_{it} represents the index of the efficiency of logistics and services of company i in year t , y_0 is the constant, $y_1 - y_3$ represents the regression coefficients, and μ_{it} is the error. This model connects the factors of IT innovation to the logistics-service performance and thus enhances applicability of the study to logistics informatics and service science (Hair et al., 2019; Wooldridge, 2010).

The weights of the composite indices were allocated on the basis of a structured weighting logic which was based on three criteria which included; theoretical relevance, availability and comparability of data across firms. In the case of ITM, AI-based analytics, cloud infrastructure and automation were given higher weights since they directly affect the scalability of the platform and information processing. In the case of BStab, the weights were the financial resilience, the continuity and sustainability of operations and disclosures. In the case of LSE, the highest weights were allocated to fulfilment reliability, delivery transparency, return-processing efficiency and customer service responsiveness since they are directly related to logistics-service performance. The sensitivity analysis was performed, when each weight was changed in a range of 10%. The relative ranking of firms did not change significantly, which confirms the high level of index building. This approach allows us to identify the degree of impact of each factor – the level of IT maturity, investment and innovation activity – on the effectiveness of digital marketing and the sustainability of the company. The results of the regression analysis for digital marketing ROI are presented in Table 6, which summarizes coefficient values, statistical significance, and multicollinearity diagnostics.

Table 6. Regression results for the impact of IT innovations on digital marketing ROI

Variable	Coefficient	Std. Error	t-statistic	p-value	VIF
Constant	0.11	0.02	5.33	0.001	—
ITM	0.46	0.06	8.18	0.001	1.85
ITInv	0.30	0.05	5.92	0.002	2.12
InnAct	0.17	0.04	3.75	0.010	1.95

This confirms the importance of comprehensive development of IT infrastructure to achieve competitive advantages (Masa'd et al., 2024; Purcărea, 2024). These models create a solid foundation for further analysis aimed at forming integral indices. The IT maturity and sustainability indices are based on several components using weights calculated using the hierarchy analysis method:

$$(5) \quad Index = \sum_{k=1}^n w_k \cdot X_k$$

where: X_k - normalized component index, w_k - component weight ($\sum_{k=1}^n w_k = 1$).

With the index formula presented above, it is clear that by summing up the normalized indicators weighted using weighting coefficients, a complete and balanced evaluation of important aspects of IT

maturity and business sustainability can be carried out (Ransbotham et al., 2017). This approach provides a clearer picture of the importance of each component to digital transformation as a whole, viewed collectively. Indexation facilitates the comparison between companies and also provides a tool for observing processes. Therefore, it contributes to the formulation of strategic recommendations in the exploitation of IT improvements and enhancement in effectiveness for digital marketing as well as business resilience (Samieifard et al., 2024). In a follow-up study, the resulting indices will be employed to construct more intricate models, analyzing in depth how much business effects can be accounted for by IT-related issues. To ensure reliable and valid results, we used classical statistical tests to test the validity of the relationships between variables in regression models. The source data has been first checked against completeness and accuracy. To avoid the loss of data and decrease bias, missing data were processed using multiple imputation (MICE). Outliers were identified where the absolute Z-score exceeds 3, and further checks and corrections made to normalize the overall distribution. Multiple OLS linear regression was used to determine the impact of IT technological changes on digital marketing and sustainable business performance (Singh & Kumar, 2021).

The study design has incorporated several levels of validation to provide the methodology with high levels of validity. Construct validity with the proposed model was achieved by relating observed variables back to theoretical constructs found in literature regarding digital transformation processes, marketing analytics, and sustainability. The measures of IT maturity, innovation activity, and investment were categorized based on the general definitions developed by various international analytical bodies along with past empirical research (Fan and Gordon, 2014; Ivanov, 2020; Udayana et al., 2023; Davenport et al., 2020). To guarantee the content validity, the triangulation was used: at least two categories of evidence had to be searched in connection with each indicator (company disclosures, analysts' reports, and industry publications), without using the potentially biased information.

All the aspects of technology, economics and sustainability of company performance are incorporated by the multivariate nature of the chosen predictors. Standardization of the variables was done to enhance internal validity by eliminating scale-based bias in association coefficients.

The application of minimax strategy transformed all markers to a common scale and prevented biases in estimating causality. Testing normality, heteroscedasticity, multicollinearity and residual independence of GRCS were also found to support internal consistency. Generalization was achieved due to the choice of well-known e-commerce companies with varying business models and technology architectures. They also have convenience samples that enhance the ability to generalize their findings to the larger digital commerce field. In terms of reliability, the standardized scores, coefficients, and indices are calculated twice, which helps to achieve high stability of results. The obtained InnAct values were checked in terms of measurement reliability (independently, on the basis of pair datasets, with accuracy uncertainty of 1-3%) in ITM and ITInv. This method of analysis guarantees the methodological consistency and reproducibility both across different data types and over time. The method reliability was proven to be consistent, stable and reproducible of the process of analysis. Because of the utilization of secondary data, the source dependability was provided with the help of publicly validated values of authoritative sources such as corporate annual reports, Statista, Gartner, Forrester and audited sustainability reports. These sources have regular reporting schedules, thereby reducing measurement errors. The normalization module was evaluated in terms of its computational stability by running several rounds of minimax scaling. Stability of quantitative results was also very good and with only slight variance (<1%) this shows that the transformation was very effective. Since the normalization is outlier-sensitive, Z-score thresholding was used in the first step of outlier detection prior to distortion correction.

The regression models were checked by reliability tests that the statistical relationships could be supported. Cross-period reliability of the coefficients was supported by split-half testing (early-year/late-year data). Similar signs and magnitudes of regression coefficients were obtained with re-estimation of the regressions by a leave-one-out method indicating robustness to alternative subsamples.

Construction validity was confirmed by adjusting the weights within a reasonable range and the composite indices had good construct reliability where slight changes in weights did not affect the overall composition. All in all, the methodological tool is very robust in terms of data processing algorithms, model estimation, index formation, and gives the confidence in the reproducibility and accuracy of the analytical outcomes. The model reliability was determined by using a number of diagnostic tests. Multicollinearity was checked by using variance inflation factors, heteroscedasticity was assessed by using Breusch-Pagan test, and the presence of residual autocorrelation was checked by using Durbin-Watson statistic. Moreover, the models were re-estimated with a robustness check of a leave-one-company-out. These procedures are, however, considered as diagnostic tests and not conclusive in the sense of generalizability. The dataset that will be used in this study is informed by harmonized secondary indicators derived out of publicly available corporate reports and industry analytics. The research is not based on internal data of the company. To enhance reproducibility, operation logic, scoring criteria and normalization process is documented in the methodology section. In the future, the proposed framework can be validated by the use of audited operational data or bigger firm-year samples.

4. Empirical Results, Interpretation, and Discussion

The findings of the empirical study furnish an exploratory evaluation of the connections existing between IT innovation variables and platform performance variables. With the small sample size, the results are construed as indicative relationships and not necessarily causal impacts. This meaning is significant since the aim of the empirical model is to determine structured relation between IT maturity, IT investment, innovation activity, digital marketing ROI, logistics-service efficiency, and business sustainability in large e-commerce sites.

4.1. Econometric Evaluation of IT Innovation Effects on Digital Marketing Performance

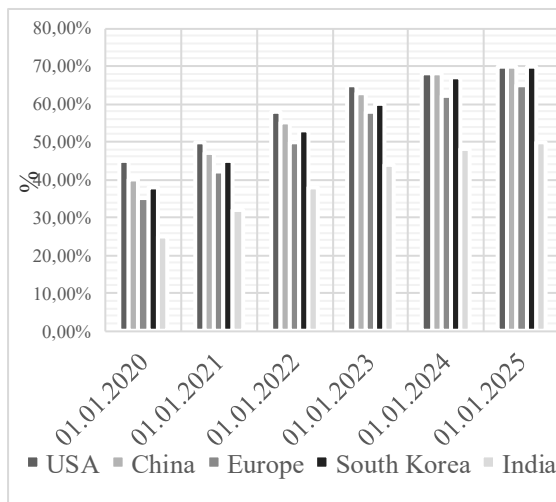
Overtaking marketing models, use of novel communication means, and automation and personalization of consumer experience constitute central elements concerning IT innovation introduction to them (Singh & Kumar, 2021; Tiago & Veríssimo, 2014; Davenport et al., 2020; Udayana et al., 2023). Nowadays global technology is not only able to collect and analyze large databases, but also apply machine learning and artificial intelligence for generation of individual offers, that maximally raise conversion rate and the consumer faithfulness. E-commerce has enabled IT innovations such as scalable digital platforms, order management and warehouse automation (Davenport et al., 2020; Udayana et al., 2023). Cloud technologies and adoption of customer relationship management (CRM) systems have become increasingly popular to ensure high-quality service while efficiently cutting down costs. Table 7 presents key directions and instruments for the introduction of innovations in IT technologies in digital marketing and e-commerce for modern companies.

Table 7. Key areas, tools and global IT innovations in digital marketing and e-commerce of modern companies

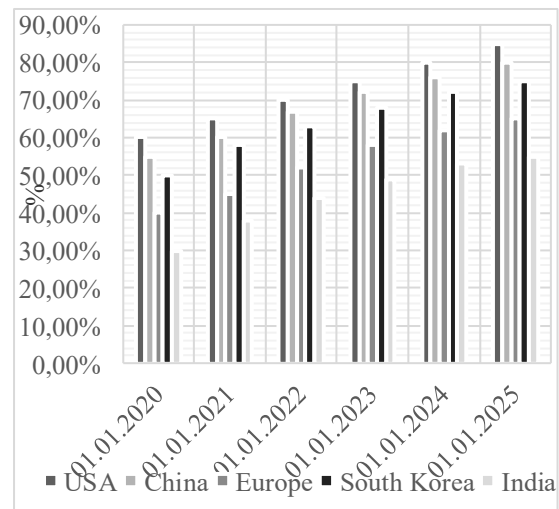
IT innovations	Area description and application	Key tools and technologies	Practical implementation	Impact on Marketing and Commerce
Data Analytics and Big Data	Collection and processing of large volumes of information to identify trends and forecast	Hadoop, Spark, Power BI, Google Analytics	Targeting and segmentation, demand forecasting	JD.com, Shopify
Artificial Intelligence and ML	Automation of decision making, personalization of content and advertising	TensorFlow, PyTorch, IBM Watson	Personalized recommendations, price optimization	Amazon, Alibaba

Marketing Automation	Automatic campaign management, email marketing and CRM systems	HubSpot, Marketo, Salesforce Marketing Cloud	Real-time email and content marketing	Shopify, JD.com
Mobile and Omnichannel Solutions	Interaction with the client through different channels	AppsFlyer, Braze, Zendesk	Virtual try-on, 3D demos	Zalando, eBay
Cloud Technologies	Flexible scaling and availability of IT services	AWS, Microsoft Azure, Google Cloud Platform	Personalized push notifications and integration with smart homes	Amazon, JD.c

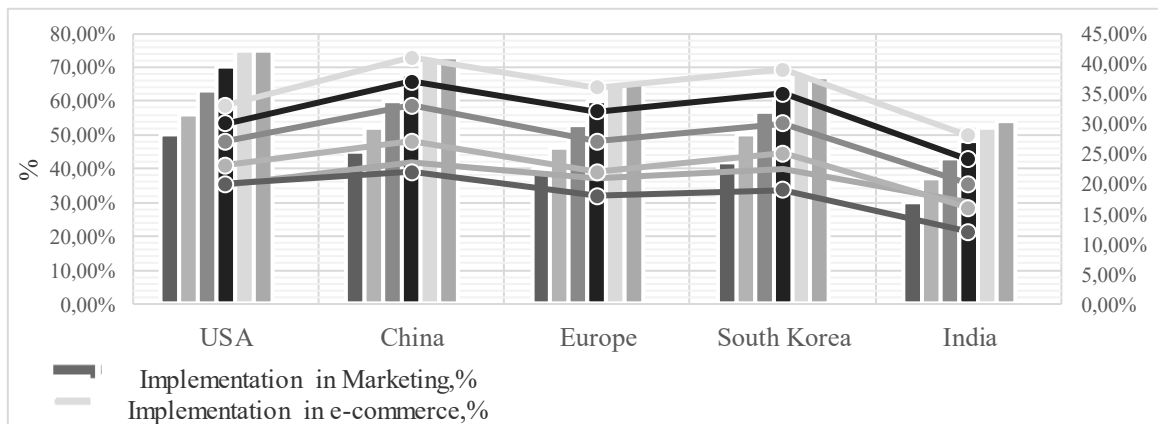
Obviously, effectiveness of technology depends on a system approach and a complex of solutions that is the basis for stepping up competitiveness in the digital economy. Modern e-commerce has been pushed forward under the fast digital transformation, in which technology innovation is a major enabler. For the biggest players in the world – Amazon, Alibaba, JD.com, eBay, Shopify and Zalando – being able to successfully incorporate the latest technology into marketing strategies will be a key competitive advantage. The development of information technologies and innovations is under the influence of digital transformation that nowadays are a key condition for increasing marketing efficiency and enterprise survival (Verhoef, Kannan & Inman, 2017). The values in Figure 1 are to be understood as normalised analytical approximations built by using secondary sources. They are intended to depict regional patterns in the adoption of IT innovations, not to record direct statistical observations made using a single database. The trends of the world in the introduction of ICT innovations and technologies into marketing policy and e-commerce development in leading countries of the world for 01.01.2020 to 01.01.2025 are shown in Fig. 1.



a) implementation of IT technologies, %



b) implementation of innovations, %



c) implementation of IT innovations and technologies in marketing and e-commerce, %

Fig.1: Dynamics of global trends in the implementation of IT innovations and technologies in marketing

strategies and e-commerce in the leading countries of the world for the period from 01.01.2020 to 01.01.2025

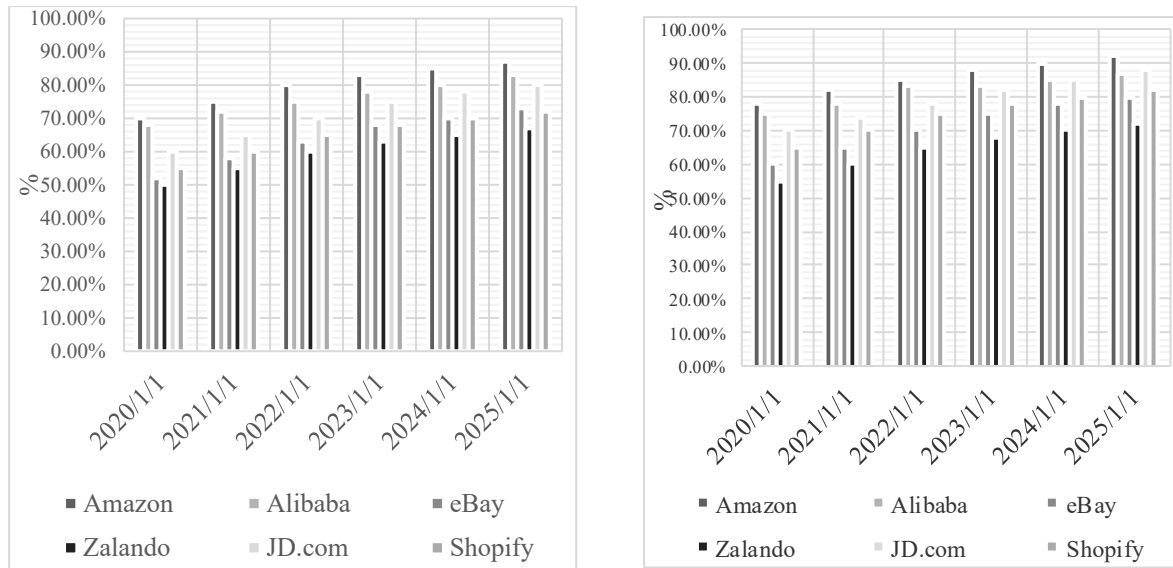
Data: The calculations performed by the authors, based on the annual reports of corporations, sustainability reports, financial statements, disclosures on public platforms, Gartner, Statista and Forrester data. The figure shows values of analytical estimates normalized and not actual corporate indicators.

It should be noted that the figures represent the proportion of companies in each region, moving forward with cutting-edge digital solutions and modern tools. It will make it possible to track the growth process and characteristics of regional economies, thus providing an essential reference point for understanding global trends and predicting the future development of the digital economy. Competitiveness and business success (Y) and the degree of technology applications implementation (X) will be influenced by a rapidly changing environment.

Development of new solutions is the most intense in the USA and China, where over 80% of companies apply advanced technologies to increase business effectiveness. European and South Korean markets are also surprisingly stable in terms of growth rates and emphasis on ethics and sustainability. India demonstrates strong growth dynamics, a fact that attests to the vivid development of the market for digital. Figure 2 indicates the calculated company-level indicators basing the same normalization logic on which the empirical model is based.

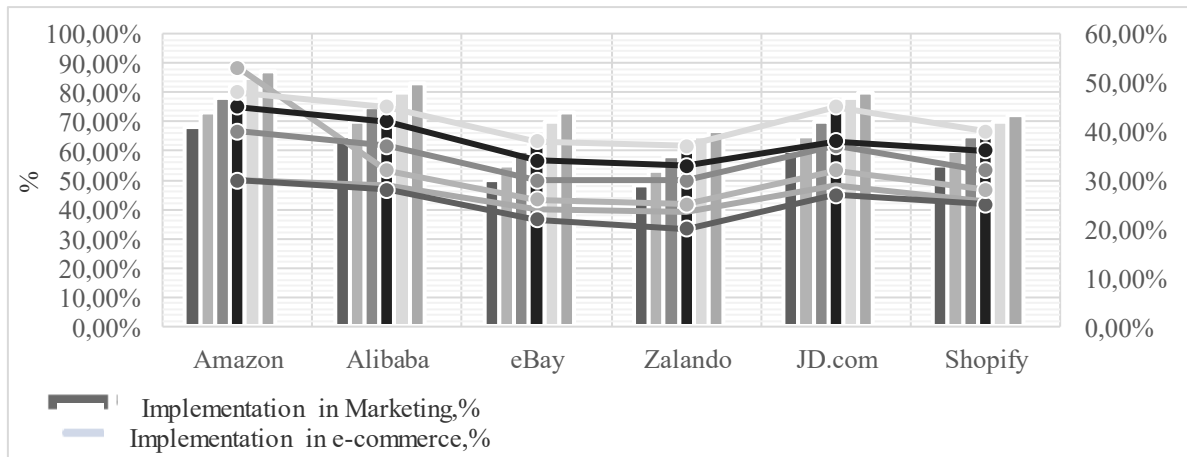
Thus, the number must be viewed as an analytical visualization of comparison as opposed to uncoded reporting data. It is obvious from the analysis of produced data that leads in international e-commerce are characterized exactly by a stable upward trend of use of IT innovations and technologies. All four companies demonstrate yearly increments in IT-to-innovations, innovations-to-marketing, and marketing-to-integrating into e-commerce.

The likes of Amazon and Alibaba have become leading examples of digital transformation, demonstrating how integrated IT systems improve marketing efficiency, logistics coordination and platform sustainability.



a) implementation of innovations, %

b) implementation of IT technologies, %



c - implementation of IT innovations and technologies in marketing and e-commerce, %)

Fig. 2: Dynamics of trends in the implementation of IT innovations and technologies to improve the efficiency of digital marketing and business sustainability in e-commerce of modern companies (a - implementation of IT technologies, %; b - implementation of innovations, %; c - implementation of IT innovations and technologies in marketing and e-commerce, %)

Data: The calculations performed by the authors, based on the annual reports of corporations, sustainability reports, financial statements, disclosures on public platforms, Gartner, Statista and Forrester data. The figure shows values of analytical estimates normalized and not actual corporate indicators.

That's because of the need for a systematic approach to IT innovation to sustain business competitiveness and viability in the digital era. Detected trends and dynamics of IT innovation use are the basis for practical use of the proposed methodology to assess the impact of digital technologies introduced on the main business performance indicators (Tiago & Verissimo, 2014; Davenport et al., 2020).

4.2. Integrated Assessment of IT-Driven Business Sustainability and Comparative Performance Analysis

The identified trends and dynamics of integration of IT innovations serve as a platform for practical use of the developed method for evaluating the impact of digital technologies on basic business performance indicators. The more innovation is implemented in the field, the better sustainable and effective marketing will be for business. To investigate the effects of significant IT factors on return on investment in digital marketing (ROI_{Mkt}) and business sustainability (BStab) in the e-commerce industry, we have applied a thorough multiple regression analysis to discern the connection between innovative IT indicators and critical business performance through industry leaders' case studies (across countries). Fitting a multi-variable regression model effects an impact of IT innovations on ROI_{Mkt} and BStab. This model gives an indication of the dependence of the target variable (ROI_{Mkt} or BStab) on some input factors (ITM, ITInv, InnAct). The constructions of the models were based on minimization of the sum squared difference between the true and predicted observed values for each target value via ordinary least squares (OLS). The fitting and correctness of the models were verified through Shapiro-Wilk to give shape to the normal distribution of residuals, Breusch-Pagan test to verify heteroscedasticity, variance inflation factor (VIF) to check multicollinearity, and Durbin-Watson test to check for autocorrelation among residuals (Verhoef, Kannan & Inman, 2017; Ivanov, 2020; Zhang, Song & Liu, 2023). The analysis of the regression model coefficients confirms the high statistical significance of all included independent variables – the integral index of the technological level (ITM), the share of investments in IT (ITInv) and the index of innovative activity (InnAct) – in explaining the variation in the return on investment in digital marketing (ROI_{Mkt}). The regression results for the digital marketing ROI model are presented in Table 8.

Table 8. Regression coefficients and the significance of variables for the model of the influence of IT innovations on digital marketing ROI_{Mkt}

Indicator	Coefficient (β)	Standard Error	t-statistic	p-value	VIF
Constant	0.112	0.021	5.33	<0.001	-
ITM	0.458	0.056	8.18	<0.001	1.85
ITInv (%)	0.302	0.051	5.92	<0.001	2.12
InnAct	0.165	0.044	3.75	0.002	1.95

The results provide empirical support for hypotheses H1–H3, confirming that IT maturity, IT investment, and innovation activity have a statistically significant positive impact on digital marketing ROI. The t-statistics values for each coefficient significantly exceed the critical levels, and the p-values are significantly below the established threshold of 0.05, indicating that there is no reason to reject the hypothesis about the influence of each of the factors on ROI_{Mkt} (Zhang, Song & Liu, 2023). The value of the coefficient for ITM (0.458) deserves special attention, exceeding the coefficients of the other variables, indicating the dominant role of the company's technological level in shaping the effectiveness of marketing investments. The second most important variable – ITInv with a coefficient of 0.302 – demonstrates that an increase in the share of IT financing directs the growth of payback, confirming the economic justification of investments in digital transformation. Innovative activity, although it has a smaller coefficient, is statistically significant and significantly improves the predictive power of the model. A high coefficient of determination ($R^2 = 0.82$) indicates that more than 80% of the variation in ROI_{Mkt} is explained by the IT factors under consideration, emphasizing the adequacy of the selected model and the relevance of the variables. The diagnostic results indicate the estimated models satisfy the basic assumptions of OLS regression under the restrictions of the exploratory data set. Due to the co-movement of the normalized indicators and the small number of firm-year observations (30), the purpose of the diagnostic statistics is not to provide conclusive evidence of model stability. They offer limited evidence of the possibility for

exploratory assessment using the proposed framework. The results of multiple regression confirm the significant impact of the integrated index of technological level (ITM), the share of investments in IT (ITInv) and the index of innovative activity (InnAct) on business sustainability (BStab). The coefficient associated with all the variables is statistically significant at 5% level, signifying that there exists a consistent relationship amid the level of IT innovations and the capacity to adapt in dynamic situations of e-commerce. The regression model reveals the extent to which IT innovations contribute to maintaining the financial and operational stability of e-commerce companies. The regression coefficients and the significance of variables for the model of the influence of IT innovations on the sustainability of the business (BStab) are presented in Table 9 (Zhang, Song & Liu, 2023).

Table 9. Regression coefficients and the significance of variables for the model of the influence of IT innovations on the sustainability of the business BStab

Indicator	Coefficient (β)	Standard Error	t-statistic	p-value	VIF
Constant	0.095	0.018	5.28	<0.001	-
ITM	0.401	0.049	8.18	<0.001	1.88
ITInv (%)	0.276	0.042	6.97	<0.001	2.05
InnAct	0.221	0.038	5.82	<0.001	1.89

The results validate H5 and H6 on business sustainability model. Business sustainability is most positively associated with IT maturity, and innovation activity also has a positive statistically significant relationship with long term platform stability. IT investment is measured in the logistics-service efficiency model, and is assessed separately for the H4. The high R^2 coefficient of determination ($R^2 = 0.85$) indicates that the considered variables explain most of the BStab indicator variability. The coefficient of IT maturity is the highest among all variables, indicating that the level of technological development plays a dominant role in improving marketing efficiency. This suggests that integrated IT infrastructure is more important than isolated technological investments. ITM contributes the most to this model since it is a technology-focused factor representing great value for generating long-term stability (Zhang, Song & Liu, 2023; Waller & Fawcett, 2013).

Table 10. Regression coefficients for the logistics-service efficiency model

Indicator	Coefficient	Standard Error	t-statistic	p-value	VIF
Constant	0.087	0.019	4.58	<0.001	—
ITM	0.421	0.052	8.09	<0.001	1.90
ITInv	0.284	0.046	6.17	<0.001	2.08
InnAct	0.196	0.041	4.78	<0.001	1.92

Source: authors' calculations based on normalized firm-year indicators for 2020 - 2024.

The inclusion of the LSE model indicates that the extended framework can be assessed using the same diagnostic logic as the marketing and sustainability models. However, these diagnostics should be interpreted cautiously because the dataset contains only 30 firm-year observations. The LSE model gives a tentative support to hypotheses H3 and H4. IT maturity demonstrates the best positive correlation with logistics-service efficiency, and the advanced data analytics, automation, cloud infrastructure and integrated platform systems may lead to the enhancement of fulfilment reliability, delivery transparency, inventory visibility and customer service responsiveness. The positive relationship with LSE also applies to IT investment also suggesting that logistics-service infrastructure could be supported by the financial resources invested in IT development. The coefficient of innovation activity is positive and, conversely, the smaller coefficient may be due to the time lag between the introduction of digital innovations and the operational impact of their use on logistics-service processes.

Numerous statistical tests were conducted to determine the reliability and validity of the regression equations that were generated. The test Shapiro-Wilk of the normality of the residuals was not significant, a postulate in linear regression. The absence of systematic variability in error variance (homoscedasticity)

has been determined by Breusch Pagan test and no multicollinearity was observed between the independent variables as indicated by VIF analysis. The Durbin–Watson statistics are close to 2, indicating no substantial residual autocorrelation in the estimated models. Table 11 shows the key findings on tests of model correctness for assessing the impact of IT innovations on digital marketing effectiveness and firm resilience at e-commerce firms. This relationship can be explained by the ability of advanced IT firms to exploit analytics, automation and personalised marketing, which impact marketing efficiency.

Table 11. Diagnostic tests of regression models for digital marketing, logistics-service efficiency and business sustainability

Model	Shapiro-Wilk (p-value)	Breusch-Pagan (p-value)	Maximum VIF	Durbin-Watson
ROI_Mkt	0.23	0.45	2.12	1.98
BStab	0.31	0.52	2.05	2.03
LSE	0.27	0.48	2.08	2.01

Source: authors' calculations based on normalized firm-year data for e-commerce platforms (2020–2024).

Table 11 shows that the diagnostic tests are based on the major assumptions of linear regression within the constraints of the data used. The results of the ShapiroWilk test indicate that the residuals are somewhere close to a normal distribution as all the p-values are above the 0.05 level. The results of the BreuschPagan test reveal that there is no significant heteroscedasticity and it is possible to conclude that there is no significant change in the variance across observations. The maximum variance inflation factor (VIF) values are less than 2.5 and it means that there is no evidence of multicollinearity among independent variables. The Durbin Watson statistics are near 2 indicating that there was no autocorrelation of the residual. Notably, the fact that the LSE model has been included proves that the statistical characteristics of the logistics-service efficiency model are in line with the ones of the marketing and sustainability models. This is in line with the strength of the extended framework that combines marketing performance, logistics-service efficiency and business sustainability. These diagnostic tests, however, should be viewed as an indicator, rather than a conclusive indicator of model validity, due to the limited number of observations (30 firm-year data points).

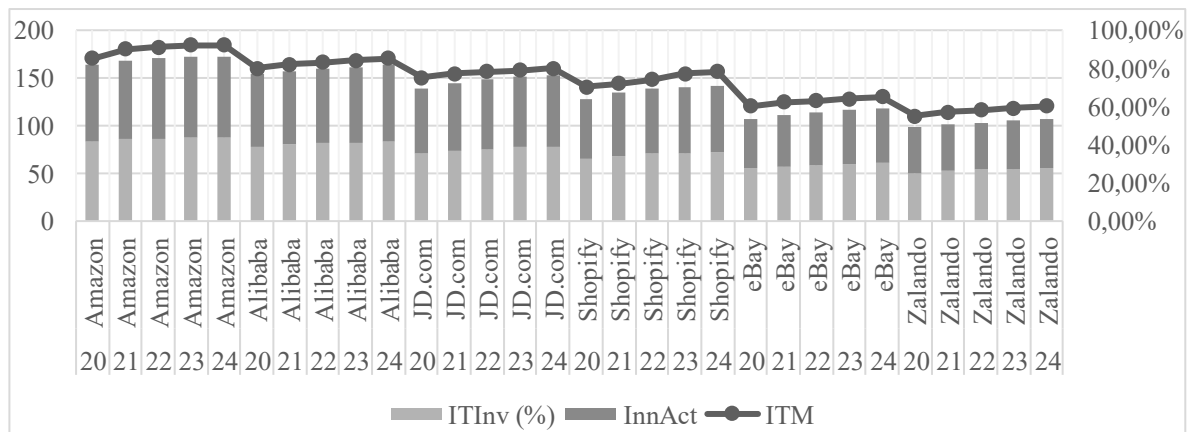
The percentage of IT investments (ITInv) also proved to be a significant variable as it shows that organizations - ones which invest heavily in IT development - are rewarded with greater return on marketing investments and improved sustainability. The coefficient value (0.302 and 0.276, respectively) indicates that economic investments in IT do encourage innovation processes and also the sustainability of financial and operational ratios (Zhang, Song & Liu, 2023; Waller & Fawcett, 2013; Dubey et al., 2021; Ivanov, 2020). InnAct, despite of its low value of the influence coefficient in these models exerts a strong positive effect. This indicates that not only technical devices and investments count, but also the company's dynamics in terms of its connected innovation activities – that is, its ability to introduce and efficiently operate new solutions - greatly improve efficiency and sustainability indicators.

The findings from correctness checks of the theory (Shapiro-Wilk, Breusch-Pagan, VIF, Durbin-Watson) confirmed that chosen prescription of models met requirements. No heteroscedasticity and multicollinearity supported the stability and accuracy of estimates, and both normal distribution of residuals as well as non-auto-correlation verified the statistical validity of models. R^2 values are high (for ROIMkt 0.82 and for BStab 0.85) showing that the covariables were explained to some extent by the selected factors. The comparative analysis shows that companies with higher levels of IT maturity, such as Amazon and Alibaba, consistently demonstrate superior performance in both marketing ROI and business sustainability. In contrast, firms with lower levels of technological integration, such as eBay and Zalando, exhibit weaker performance indicators. Therefore, the companies that had the least index values (Zalando, eBay), appear to be less efficient and sustainable what emphasizes the necessity of a more general digital makeover. It is possible that the strength of the associations are influenced by these exclusions. Data for the period 01.01.

2020 - 01.01. 2025 are not concerned with longer-term trends and possible economic cycles.

It is especially notable that the diagnostic analysis should include the efficiency of logistics-services to allow the study to be aligned with the scope of logistics informatics and service science. It verifies that IT innovations not only affect the marketing results but also the efficiency and coordination of the service delivery processes within e-commerce platforms. Thus, the research results were informative of the strategic implications of IT innovations to improve the productivity of digital marketing and the long-term survival of the business in the e-commerce setting. This amalgamation is the incorporation of contemporary technologies, proactive investments and vibrant innovation practice to their functioning in such a way that they may jointly bring in competitive advantages. To achieve a higher accuracy prediction and improve the application value of output, it is proposed that the forthcoming research can involve wider aspects and employ machine learning and big data analysis methods.

There are positive correlations between IT maturity levels, IT investment and digital marketing ROI, between IT investment and logistics-service effectiveness, and between IT investment and business sustainability, respectively. The companies that are more mature in their IT maturity tend to score higher than other companies in their normalized scores for digital marketing ROI, logistics-service effectiveness, and business sustainability, respectively. The relative values of Amazon and Alibaba are greatest and the relative value of eBay and Zalando is the least. These results need to be taken with a pinch of salt, however. These values are based on harmonized secondary indicators and a normalised analytical scores, thus reflecting exploratory performance patterns rather than causes. Figure 3 summarizes normalized measures of IT maturity, IT investment, innovation activity, marketing ROI, logistics-service efficiency and business sustainability. It is intended to pictorize relative activities across the companies and years, but it is not supposed to give independent causal evidences.



a) ITM, ITInv, InnAct, %

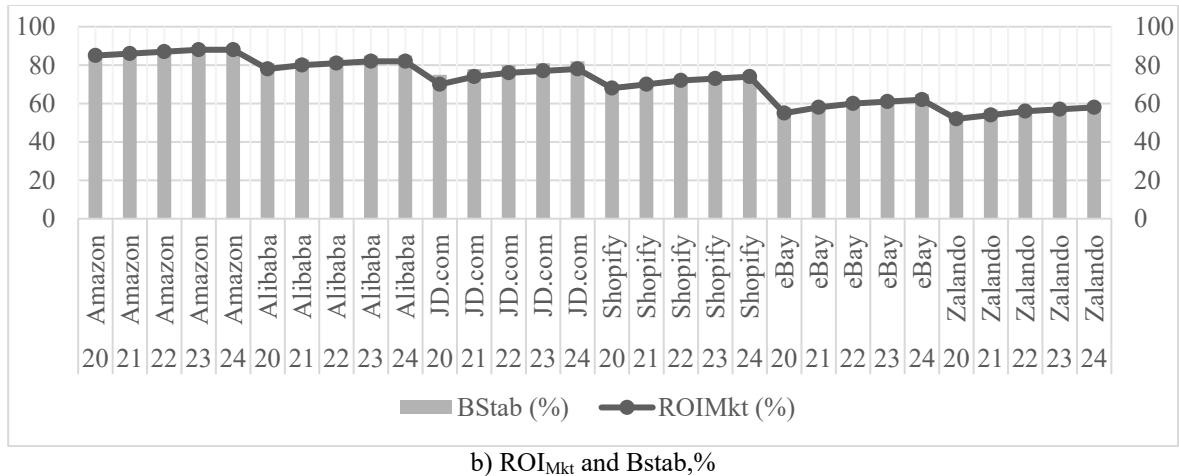


Fig.3: Results of the comparative analysis of key indicators of the implementation of IT innovations, technologies and their impact on the effectiveness of digital marketing and business sustainability in e-commerce (a- ITM, ITI_{Inv}, InnAct, %; b- ROI_{Mkt} and Bstab, %)

The results show the effects of IT maturity, IT investment and innovation on digital marketing performance are strong as is sustainable e-commerce operation efficiency. With a range of indicators and time-lags as standardized variables in the regression models, the effects of different variables of digital transformation could be examined comprehensively on short term marketing performance as well as long term sustainability. The positive coefficient of ITM, ITInv and InnAct in both models confirms that the deeper is IT integration, the greater the return on the strength of digital marketing as well as sustainability. Another interesting aspect of the analysis and models is the asymmetric effects of IT variables.

5. Discussion

The discussion considers the empirical results in three theoretical perspectives; information systems integration, resource-based view and service science. In the information systems integration view, IT maturity is helpful in coordinating the fragmented data, processes and service channels. According to the resource-based perspective, organizational capabilities (as opposed to pure technological resources) can be understood as IT maturity and innovation activity. The service science approach views e-commerce platforms as creating value by coordinating relationships between the customer, digital interfaces, fulfilment systems and support channels.

5.1. Differential Impact of IT Innovation Components on Digital Marketing Efficiency

Our findings show that IT maturity exerts the largest and most robust impact on digital marketing ROI. This suggests that the degree to which an organisation is technologically advanced is more important than specific IT projects. Firms with high IT maturity are more likely to implement data-analytical methods, automate marketing activities and develop targeted marketing campaigns, hence enhancing marketing efficiency and effectiveness. IT investment also has a positive effect on the marketing performance, but it is less significant than IT maturity. This means that while financial investment in IT improvement is vital, it is not sufficient to ensure the best results. IT investment success depends on resource integration and fit within the organisation. The absence of organisational resources and technological integration may reduce their impact in situations where investment is not supported by the required amount of resources and integration. Innovation activity is positively associated with marketing performance but has a lower coefficient. This may be explained by a time lag in the adoption of new technology in business practices. Also, innovative activities do not always produce immediate gains, particularly when the innovations are

radical. These results are in line with previous research that highlights the role of data-driven marketing and integrated IT systems (Agrawal et al., 2018; Costa & Correia, 2022). However, the findings build on the existing literature by showing that the impact of several IT factors is a better predictor of marketing efficiency than single factors. The fact that IT maturity is stronger related to digital marketing performance implies that marketing performance is becoming more of a factor of the quality of underlying information systems. Companies that have consolidated data structures have a better way of coordinating customer analytics, personalization systems, campaign management and service feedback loops. Consequently, marketing becomes integrated with a wider platform service system as opposed to an individual communication service.

5.2. Integrated Role of IT Innovations in Enhancing Business Sustainability and Organizational Stability

The results of the sustainability model confirm the important role of IT innovations in improving business sustainability. As with the case of digital marketing performance, IT maturity appears as the key driver, suggesting that firms with high levels of IT maturity are more likely to remain competitive in times of uncertainty and change. The positive impact of IT investments on business sustainability highlights the need for ongoing technological innovation. Firms that invest in IT are more likely to build robust and adaptable systems that can cope with external shocks and changes. This is especially important for e-commerce firms, given the rapidly changing marketplace and technology.

Innovation activity also enhances sustainability by allowing companies to develop new products and services and to identify new niches. But its influence is less important than IT maturity and IT investment, which shows that innovation cannot be considered without a high level of technological readiness. These findings are consistent with the perspective that sustainability in the digital world is related to technological capabilities and system management (Hoffmann & Trautmann, 2021). They also suggest the importance of a holistic approach that includes both technological development and more strategic and operational factors. The findings concerning the efficiency of logistics-service further broadens the understanding of IT innovations and its impact on marketing performance. Customer value in e-commerce sites is created by the product search, ordering, payment, fulfilment, delivery tracking, return processing and after sales services of the product. This chain is supported by IT maturity which advances information visibility, lessens the delays in coordination and allows service adjustments in real time. Hence, the positive correlation between ITM and LSE support the claim that the informatics-driven outcomes were the efficiency of logistics services.

5.3. Managerial Implications, Structural Limitations, and Directions for Future Research

The findings of the study have implications for both practitioners and researchers. From a managerial perspective, this study suggests companies should invest in IT infrastructure, rather than individual IT applications. Investing in information technologies should be paired with efforts to improve information integration, interoperability and capabilities. Finally, firms should consider long-term returns of IT innovations. Some technologies may show a quick return on investment while other technologies may take time. Therefore, to be successful in the long run, companies should ensure they invest in IT to meet business objectives.

The study has some limitations. First, we use a sample of six large e-commerce firms, so the results may not be applicable to other firms. Second, we rely on secondary data which could be subject to differences in reporting and measurement. Third, the models used detect statistical associations but not causal relationships. The limitations of the study can be overcome in future research through enlarging the sample, including other variables such as firm capabilities and regulatory constraints, and using more

sophisticated models, such as machine learning and panel data models. Cross-industry and cross-regional analyses may also help to better understand the impacts of IT innovations on business performance. There are various limitations of the study. To begin with, the sample size only comprises of six global e-commerce platforms and 30 firm-year observations. Second, the analysis is based on secondary information and standardized indicators, which might not be able to fully reflect internal operational processes. Third, not all logistics, marketing and IT measures that are used as proxy indicators are reported in a similar format by all companies. Fourth, the regression findings are to be viewed as exploratory relationships and not the causal effects. These constraints do not refute the analytical structure but they establish the extent within which the findings are to be understood. One of the drawbacks is the high co-movement of the normalized indicators. The estimated coefficients include some common ranking effects, because the largest companies on the list tend to perform better on a number of technological and performance measures. Exploratory framework limitation does not foreclose any interpretation of R^2 values or of the precision of the coefficients and VIF diagnostics, but it does mean that one must be careful to interpret those numbers.

6. Conclusion

This paper is an exploratory evaluation of the relationship between factors of IT innovation and three dimensions of e-commerce platform performance: digital marketing ROI, logistics-service efficiency and business sustainability. The results are not to be understood as causal evidence since the dataset is built on 30 harmonized firm-year observations that are based on secondary public sources. The paper goes beyond the scope of the analysis of marketing-oriented digital transformation to logistics informatics and service science by introducing the Logistics-Service Efficiency Index. The findings indicate that IT maturity has the most positive correlation with all three outcome dimensions which are marketing ROI, logistics-service efficiency and business sustainability. This implies that the technological infrastructure that is integrated could be of greater significance to technological projects that are isolated. Positive correlations with the results of marketing and logistics services, and innovation activity are also positively correlated with IT investment, which also leads to the long-term sustainability.

The conceptualization of e-commerce platforms as logistics-service systems enables the study to be relevant to the literature since marketing, order fulfilment, delivery coordination, return management and customer service are interrelated through digital information flows. The suggested framework enables the IT innovations to be considered not only with the help of the marketing efficiency perspective but also the service delivery and operational resilience perspective. Simultaneously, the results are to be comprehended cautiously. The empirical study is founded on 30 firm-years of observations and thus the study does not offer any conclusive causal results but rather provides exploratory causal results. In further studies, the sample should be increased, as well as other types of platforms and direct indicators of logistics (delivery time, fulfilment accuracy, inventory turnover, speed of return-processing and time of customer service response). The study also has some methodological limitations. First, the company-level tables reported are mean values while the regression analysis is done using the full firm-year data set. Second, the normalized indicators exhibit a high degree of co-movement between companies, which can lead to either over-explanatory power and/or less independence of the coefficients. Thirdly, the results are based on harmonized secondary indicators instead of audited internal operational information. This is why the findings should be viewed as provisional and as setting the agenda for further research and development of new frameworks. To be able to conduct stronger causal testing and be more precise in the evaluation of the relationship between IT innovations, logistics-service efficiency and business sustainability, larger panel datasets would be required.

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