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Futures in the making

- Developing and adapting futures in business

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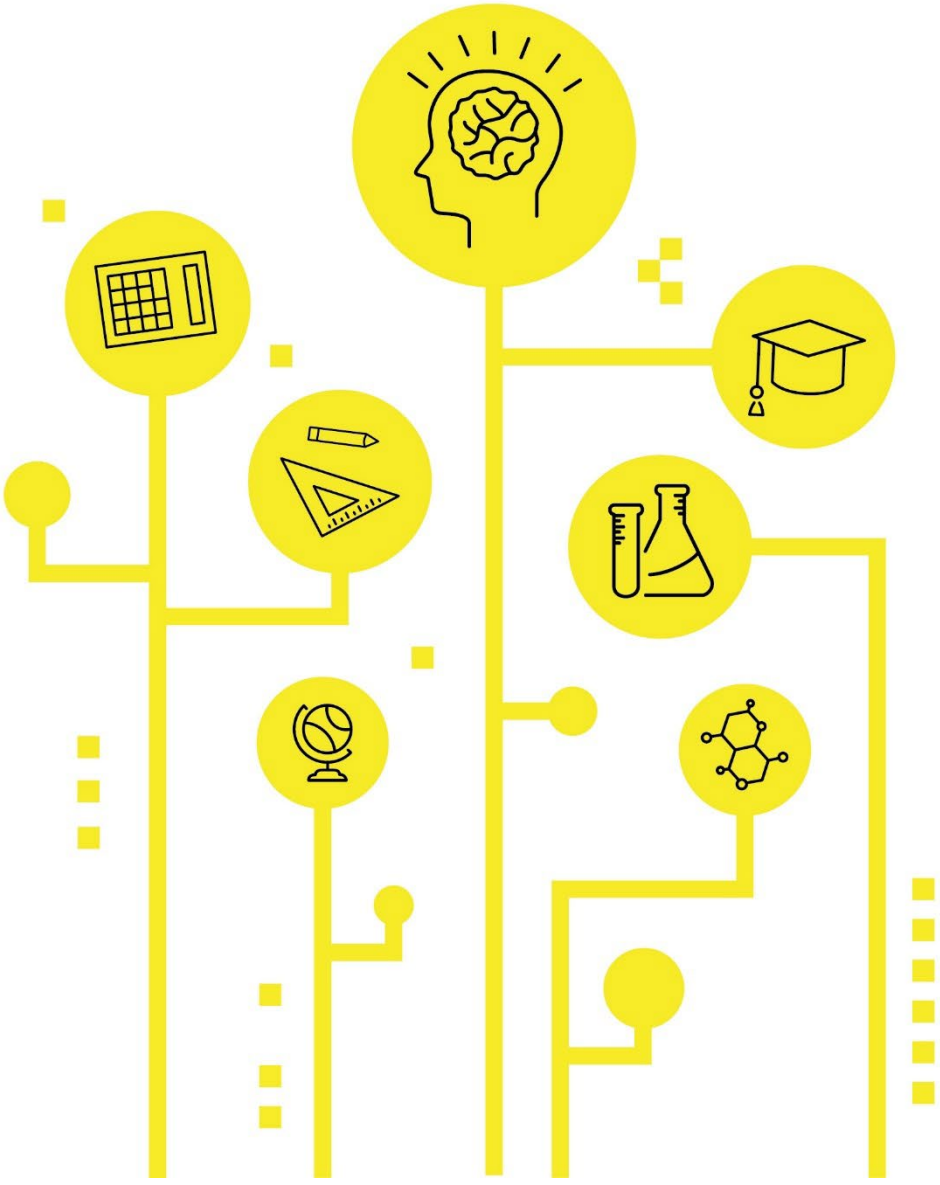

Futures in the making - Developing and adapting futures in business – BUEB Day of Hungarian Science 2024

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Digital Financial Literacy Matters

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Abstract

This paper investigates the level and socio-demographic determinants of digital financial literacy among adults in 15 European countries. It draws on data from the most recent (2023) survey conducted by the International Network of Financial Education (INFE) of the Organization for Economic Development (OECD), which includes large, representative national samples and standardized data collection. A series of statistical analyses was conducted to assess the extent to which adults using digital financial products and services in the countries observed meet the minimum required level of digital financial literacy and whether digital financial literacy scores vary significantly across groups defined by gender, age, educational attainment, income level, and size of settlement.

The results indicate that the overall level of digital financial literacy is relatively low across the countries examined, is unevenly distributed and falls below the OECD average. Of the variables analyzed, educational attainment and income level showed a statistically significant impact on digital financial literacy scores, with moderate effect sizes. Gender, age, and size of settlement did not show a significant influence. Hungary ranks in the lower half of the observed countries. The findings underscore the need for continued efforts to improve digital financial literacy across Europe.

Keywords: digitalization; financial literacy; digital literacy; digital financial literacy; FinTech; statistical methods

JEL classification: G53

Introduction

Digitalization is a key trend reshaping both the present and the future. It brings about fundamental transformations across all areas of economic and social life, from production processes and supply chains to sales, marketing, transportation, consumption, public administration, communication, healthcare, education, and even the arts and leisure activities.

The digitalization of finance is currently a highly relevant and widely discussed topic. This is unsurprising, given that digital transformation is reshaping the entire financial architecture — including the institutions, policies, regulations, and practices that underpin the financial system. As a result, customers are expected to adapt to this evolving new environment and develop the necessary skills and competencies to successfully navigate the digital financial landscape and achieve their financial objectives (Zaika, 2024).

Digitalization accelerated following the global financial crisis and has unfolded in three major phases up to the present day:

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1. **Pre-pandemic phase (circa 2008–2019):**
   This period was characterized by the rise of Financial Technology (FinTech) startups, emerging largely as a response to the erosion of trust in traditional banks after the global financial crisis. These newcomers embraced technology to deliver enhanced digital customer experiences and began to gain a foothold in the financial services sector (Ross et al., 2023).
2. **Pandemic phase (2020–2022):**
   During the COVID-19 lockdowns, digitalization surged as institutions rapidly developed online platforms and Information Technology (IT) infrastructure. The primary objective was to ensure operational continuity and deliver a seamless, digital-first customer experience despite physical restrictions (Moden and Neufeld, 2020).
3. **Post-pandemic phase (2023–present):**
   With the immediate pandemic pressures of the pandemic easing, the FinTech landscape has shifted towards greater collaboration and ecosystem-building. Partnerships between traditional financial institutions and FinTech companies have become increasingly common, supported by regulatory frameworks which encourage data-sharing and foster integrated service platforms (Thompsett, 2024).
   Digitalization is rapidly transforming the financial sector, with digital financial services becoming increasingly widespread — and in many cases, establishing themselves as the new norm**.** Consumers are now more likely to purchase goods and services online and to manage their finances through digital platforms. Between 2014 and 2021, the global share of individuals who made or received digital payment rose significantly — from 44% to 64%. Among countries in the Organization for Economic Co-operation and Development (OECD), this figure reached an impressive 96% (Demirgüç-Kunt et al., 2022, pp. 53–76). Since then, the pace of digital adoption has continued to accelerate, further reinforcing the shift toward a fully digital financial ecosystem.

Digital financial services offer numerous benefits, but they also present significant challenges**.** On the one hand, these services are widely recognized for being convenient, fast, cost-effective, and user-friendly. They enhance accessibility and promote financial inclusion, offer innovative financial solutions, and — when properly implemented — can offer a secure and effective means of fraud prevention.

On the other hand, digital financial services raise serious concerns related to security, data privacy, and regulatory compliance. They also entail technological risks, increase the potential for overspending, and may contribute to digital financial exclusion — particularly among vulnerable groups lacking access to digital infrastructure or the necessary digital skills. Crucially, these services require a certain level of digital financial literacy, without which users may struggle to navigate the digital financial environment safely and effectively.

In today's increasingly digital financial landscape, digital financial literacy has become an essential competency. As such, it is not merely a blend of traditional literacies, but a distinct and evolving skill set in its own right. Low levels of digital financial literacy can adversely affect not only individual financial well-being but also the stability of the financial system and, ultimately, societal resilience. Conversely, improving digital financial literacy — alongside robust regulatory frameworks and consumer protection mechanisms — can empower individuals to protect themselves online and make informed use of FinTech tools. This, in turn, supports the development of a secure and inclusive financial sector and contributes to broader societal well-being.

Defining Digital Financial Literacy

The concept of digital financial literacy has its origins in three foundational domains: *literacy*, *financial literacy*, and *digital literacy*. It draws upon and integrates key elements from each of these fields, while also incorporating unique features that reflect the specific characteristics, complexities, and risks associated with digital financial products and services.

- **Literacy**

While various definitions of literacy have been proposed by both researchers and practitioners, this paper adopts the definition provided by one of the internationally recognized organizations, particularly the OECD.

According to the OECD (2024, pp. 58–59)**,** *literacy* is defined as:

> "the ability to understand, evaluate, use and engage with written texts to participate in society, to achieve one's goals, and to develop one's knowledge and potential. […] This definition does not involve either comprehending or producing spoken language or producing text (writing)."

The OECD further classifies literacy into **six proficiency levels**: Level 1 to Level 5, and below Level 1.

- At Level 1, individuals are able to understand short texts and structured lists where the required information is explicitly stated. They can locate specific details and make simple inferences.
- Those below Level 1 can comprehend, at most, short and basic sentences.
- At the upper end, individuals at Level 4 or 5 can interpret complex, extended texts, identify implicit meanings, and apply prior knowledge to perform sophisticated tasks.
- Levels 2 and 3 represent intermediate literacy skills and are also described in detail in the OECD framework.

This comprehensive structure emphasizes the nuanced range of literacy skills necessary for navigating modern information environments**,** including — but not limited to — financial and digital domains.

- **Financial Literacy**

In this paper, the definition of *financial literacy* is based on the widely accepted framework developed by the International Network of Financial Education (INFE) of the OECD:

> "Financial literacy is a combination of financial awareness, knowledge, skills, attitudes, and behaviors necessary to make sound financial decisions and ultimately achieve financial well-being." (OECD/INFE, 2023, p. 13)

Financial literacy enables individuals to make informed financial decisions and exercise greater control over their personal finances. It enables them to critically assess financial products and services, understand associated risks and opportunities, and navigate the financial system with increased confidence.

Beyond its informational value, financial literacy serves a protective function. It helps individuals avoid financial fraud, resist manipulative marketing tactics, and build the confidence needed to explore and adopt new financial tools and technologies. Importantly, it also fosters positive financial behaviors, such as saving and investing, which are essential for managing short-term financial volatility and achieving long-term financial goals.

As digital financial services become increasingly prevalent, financial literacy plays an even more pivotal role in ensuring that consumers can actively and safely participate in the evolving financial landscape.

- **Digital Literacy**

This paper adopts the definition of *digital literacy* provided by UNESCO (2018):

"Digital literacy refers to the ability to access, understand, communicate, and create information through digital devices and technologies."

Digital literacy encompasses a broad set of competencies that enable individuals to engage meaningfully and safely in a digital society. According to UNESCO, this includes both generic Information and Communication Technology (ICT) skills—such as using search engines, word processing applications, spreadsheets, or online communication platforms—and more advanced ICT skills, such as programming, coding, or managing complex digital systems.

While basic digital literacy equips individuals to operate in everyday digital environments (e.g. sending emails, conducting online searches, or participating in social media), more advanced levels of digital competency are becoming increasingly essential in a knowledge-driven economy. These skills are also essential for navigating digital services — particularly in the context of FinTech, where users are expected to navigate sophisticated platforms, manage sensitive data, and make secure online transactions.

Digital literacy, therefore, forms a foundational pillar of digital financial literacy. It not only enables consumers to access digital financial tools but also empowers them to do so in a safe, critical, and informed manner.

- **Digital Financial Literacy**

According to the OECD INFE (2023, p. 7), *digital financial literacy* is defined as:

"a combination of knowledge, skills, attitudes, and behaviors that enable individuals to be aware of and safely use digital financial services and technologies, with the ultimate goal of enhancing their financial well-being."

Digital financial literacy is recognized as a distinct subset of overall financial literacy, reflecting the unique challenges and opportunities presented by the digitalization of financial services. It encompasses not only a sound understanding of traditional financial concepts but also the ability to navigate, evaluate, and securely interact with digital platforms, tools, and innovations within the financial ecosystem.

Literature Review

The academic literature specifically addressing digital financial literacy, as defined above, remains relatively limited, primarily due to the recent emergence of the concept alongside the rise of FinTech. In contrast, financial literacy has been the subject of extensive research over a longer period, followed more recently by a growing body of research on digital literacy. These foundational areas are therefore considered well-established and widely recognized.

FinTech — defined as the provision of financial services to consumers through digital devices utilizing software, applications, and platforms — has ushered in a new era marked by significant opportunities, particularly in the realm of financial inclusion. This development initially led to the implementation of practical solutions, which have since been complemented by an expanding body of methodological and empirical research.

Regarding practical measures, the first Global Findex database — a worldwide survey tracking country-level financial inclusion — was launched in 2010. In the same year, the Group of Twenty (G20) introduced the Financial Inclusion Action Plan (FIAP) with the objective of

expanding access to financial services. To support its implementation, G20 also established the Global Partnership for Financial Inclusion (GPFI). The FIAP was revised in 2014 to reflect emerging developments, including the growing significance of FinTech. As part of this revision, a commitment was made to implement the G20 Principles for Innovative Financial Inclusion, based on a shared vision of universal access to financial services (BIS, World Bank, 2016). In 2016, G20 leaders formally acknowledged the role of digital financial literacy in harnessing the benefits of FinTech and endorsed the High-Level Principles for Digital Financial Inclusion. Notably, Principle 6 emphasized the need to 'Strengthen Digital and Financial Literacy and Awareness' (GPFI, 2016). The Findex database was updated in 2021, revealing a substantial increase in global financial inclusion over the previous decade (Demirgüç-Kunt, Klapper, Singer & Ansar, 2022).

With regard to collecting and providing systematic data, the International Network on Financial Education (INFE) of the OECD expanded its regular financial literacy survey in 2022 to assess both the extent to which consumers use digital financial services and their level of digital financial literacy. Accordingly, the survey's Toolkit was revised to incorporate these new dimensions (OECD/INFE, 2023).

The significance of digital financial literacy in the digital era has been highlighted by researchers from the Asian Development Bank Institute — Morgan, Huang, and Trinh — who emphasized the need for a clear conceptual framework. Building on previous efforts, they proposed a formal definition of digital financial literacy and called for the development and implementation of assessment and capacity-building tools, with particular attention to vulnerable population groups. They identified four key dimensions of digital financial literacy: (1) knowledge of digital financial products and services, (2) awareness of digital financial risks, (3) understanding how to manage and mitigate these risks, and (4) knowledge of consumer rights and redress mechanisms (Morgan, Huang & Trinh, 2019).

Lyons and Kass-Hanna (2021) conducted a comprehensive review and evaluation of methodological approaches used to define, measure, and analyze (a) financial literacy, (b) digital literacy, and (c) digital financial literacy. In addition, they introduced recent methodologies for constructing, testing, weighting, and standardizing multidimensional indices of digital financial literacy, with the aim of advancing empirical research in this evolving field.

A bibliometric analysis of digital financial literacy research was conducted by Yadav and Banerji (2023), drawing on data from the Scopus and Web of Science databases for the period 2014 to 2022. Using a web-based tool, they found that, as an interdisciplinary field, the thematic focus of digital finance research has evolved over time. Early studies primarily concentrated on socioeconomic and demographic variables; however, more recent research has broadened to encompass factors such as behavioral influences, promotional strategies, and other determinants affecting digital financial literacy.

Koskelainen, Kalmi, Scornavacca, and Vartiainen (2023) conducted a literature review aimed at exploring how digitalization influences individuals' financial literacy and financial capability. Their analysis revealed that research situated at the intersection of finance and digitalization predominantly centers on three thematic areas: FinTech, financial behavior in digital environments, and behavioral interventions. Based on these insights, they proposed a conceptual framework illustrating how these themes shape the knowledge, skills, and tools associated with traditional financial literacy and financial capability.

An increasing number of studies have specifically investigated digital financial literacy across various countries. While not exhaustive, notable examples include: Shen, Hu, and Hueng (2018), who examined the impact of financial literacy, digital financial product usage, and internet access on financial inclusion in China; Choung, Chatterjee, and Pak (2023), who explored the

relationship between digital financial literacy and financial well-being among Korean adults; Prasad, Meghwal, and Dayama (2018), who assessed the level of digital financial literacy in Indian households; and Schuhen et al. (2022), who reported on the digital financial literacy of adults in Germany.

Despite the significant progress made by leading international organizations and researchers, there remains substantial scope for further exploration and deeper understanding in the realm of digital financial literacy.

Research Objectives, Questions and Hypotheses

Having reviewed the conceptualization and significance of digital financial literacy, as well as the existing literature on the topic, it becomes evident that further investigation through quantitative research is warranted. This study, therefore, aims to examine digital financial literacy among the adult population in Europe and to analyze the factors influencing it using a comparative approach.

- **Research Objectives**
  1. To assess the level of digital financial literacy among the adult population in Europe.
  2. To explore cross-country variations in the level of digital financial literacy across Europe.
  3. To identify and analyze the socio-demographic factors that influence digital financial literacy.
- **Research Questions**
  1. What is the current level of digital financial literacy among the adult population in Europe?
  2. Are there significant differences in digital financial literacy levels among various European countries?
  3. Which socio-demographic characteristics (e.g., gender, age, educational attainment, income level) influence digital financial literacy and to what extent?
- **Hypotheses**
  - **H1:** The level of digital financial literacy among individuals is relatively low in the selected European countries and does not meet the requirements for the safe and effective use of digital financial products and services.
  - **H2:** Digital financial literacy is significantly influenced by key socio-demographic factors, including gender, age, educational attainment, income level, and size of settlement in the selected European countries.
    - **H2a:** There is a significant difference in digital financial literacy between men and women.
    - **H2b:** Younger individuals demonstrate higher levels of digital financial literacy compared to older age groups.
    - **H2c:** Individuals with higher levels of formal education have significantly greater digital financial literacy than those with lower educational attainment.
    - **H2d:** Higher income levels are positively associated with digital financial literacy.
    - **H2e:** Individuals living in larger settlements exhibit higher digital financial literacy compared to those living in smaller ones.

Methodology

- **Research Design**

This study applies a quantitative research design to assess the level of digital financial literacy among adults in the selected European countries. The research also aims to compare differences across countries and to identify key socio-demographic factors influencing digital financial literacy.

- **Data Source**

The analysis is based on secondary data obtained from the OECD/INFE 2023 International Survey on Adult Financial Literacy (OECD/INFE, 2023). This dataset is internationally recognized as the most up-to-date, reliable and comprehensive source of comparable data on financial literacy. For the first time, the 2023 wave of surveys includes a section dedicated to digital financial literacy, allowing for an in-depth investigation of this emerging topic.

The survey was conducted in 39 countries and economies, including 20 OECD member states (among them Hungary) and 8 G20 countries, with a total sample of 68,826 adult respondents aged 18–79. Data were collected through nationally representative surveys carried out by the relevant authorities in each participating country. The measurement framework is based on the OECD/INFE Toolkit, which was revised and endorsed in 2022.

- **Country Selection**

This study focuses on European countries for which complete and comparable data on digital financial literacy are available from the OECD/INFE 2023 International Survey. A total of **15 European countries** were included in the final sample: Croatia, Cyprus, Estonia, Finland, France, Germany, Greece, Hungary, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Romania and Sweden**.**

To provide a broader comparative perspective, the OECD average reported in the dataset was also included. This benchmark serves as a reference point for evaluating the relative performance of the European countries.

- **Variables and Measurement**

The primary dependent variable is the digital financial literacy score, which comprises multiple items that capture knowledge, awareness of risks, risk management, and understanding of consumer rights in digital financial contexts.

Independent variables include:

- Gender,
- Age group,
- Educational attainment,
- Income level,
- Size of settlement.

These variables were selected based on availability and relevance within the OECD/INFE dataset.

- **Statistical Analysis Plan**

To address the research objectives and test the proposed hypotheses, the following statistical analyses were conducted:

  - Descriptive Statistics
  - Analysis Based on Proportional Indicators
  - Correlation Analysis Between Digital Financial Literacy and Selected Socio-Demographic Factors
  - Analysis of Variance (ANOVA)

- Measures of Association

- **Software**
  All statistical analyses were conducted using IBM SPSS.

Results

Descriptive Statistics – Digital Financial Literacy

To test Hypothesis 1 (H1), which posits that the level of digital financial literacy among customers using digital financial services is relatively low and insufficient in the selected European countries, a descriptive statistical analysis was conducted based on data from the OECD/INFE 2023 International Survey on Adult Financial Literacy.

The analysis covers 15 European countries and focuses on the digital financial literacy scores of the adult population, expressed on a scale of 0 to 100. A benchmark score of 70 points is considered the minimum adequate level of digital financial literacy, based on OECD guidelines and international best practices.

Table 1 presents the digital financial literacy scores across the European countries. For comparative purposes, traditional financial literacy scores are also included, along with the difference between the two measures.

Table 1: Digital and Traditional Financial Literacy Scores of Adults across 15 European Countries
Source: Author's calculations based on data from OECD (2023)

No.	Country or Economy	Digital Financial Literacy Score (out of 100) across all adults (1)	Traditional Financial Literacy Score (out of 100) across all adults (2)	Difference between Traditional and Digital Financial Literacy Scores (2-1)
1	Croatia	49	62	13
2	Cyprus	44	56	12
3	Estonia	64	67	3
4	Finland	61	65	4
5	France	62	62	0
6	Germany	64	76	12
7	Greece	54	61	7
8	Hungary	48	58	10
9	Latvia	46	59	13
10	Lithuania	45	56	11
11	Luxembourg	59	68	9
12	The Netherlands	56	64	8
13	Poland	50	62	12
14	Romania	44	54	10
15	Sweden	52	66	14
	Mean	**53**	**62**	**9**
	Median	**52**	**62**	**10**

	Minimum	**44**	**54**	**10**
	Maximum	**64**	**76**	**12**
	Standard Deviation	**7.2**	**5.5**	**4.0**
	OECD Average	**55**	**63**	**8**

The average digital financial literacy score (mean) across the 15 European countries is **53** (out of 100), which falls significantly below the target threshold of 70.

The median score is 52, reinforcing the view that more than half of the adult population in the sample does not reach the minimum expected level of digital financial awareness.

The lowest observed score **is** 44 (recorded in Cyprus and Romania), while the highest score is 64 (recorded in Estonia and Germany), still falling short of the benchmark.

For comparison, the average traditional financial literacy score (mean) is 62, which is 9 points higher than the average digital financial literacy score. This gap illustrates a substantial difference in literacy levels between traditional and digital financial contexts.

Hungary scores below the sample average in both traditional and digital financial literacy.

Furthermore, data show that the selected European countries lag behind the OECD average. Their disadvantage is slightly greater in digital financial literacy (−2 points compared to the OECD average) than in traditional financial literacy (−1 point).

These findings support Hypothesis 1 (H1), as they demonstrate that the current level of digital financial literacy among adults in the selected European countries is relatively low and insufficient, particularly when measured against the 70-point benchmark.

The results also highlight considerable variation across countries, suggesting that factors such as national education systems, digital infrastructure, and financial inclusion policies may influence literacy levels.

- **Analysis Based on Proportional Indicators**

This section examines the relationship between digital financial literacy and the use of digital financial services across the selected European countries, focusing on *three key indicators*:

- Proportion of adults reaching the minimum digital financial literacy score (≥70/100 points)
- Proportion of adults who manage financial products and services online
- Proportion of online financial service users who reach the minimum digital financial literacy score (≥70/100 points)

Table 2: *Adequate Digital Financial Literacy and Digital Service Use*
Source: *Author's calculations based on data from OECD INFE 2023*

No.	**Country or Economy**	**Minimum Digital Financial Literacy (at least 70 points out of 100 points) across all Adults (percent)**	**Adults who Manage Financial Products and Services Online (percent)**	**Adults who Score the Minimum Target Digital Financial Literacy Score, out of those who Manage Financial Products and Services Online (percent)**

1	Croatia	21.8	24.3	32.2
2	Cyprus	10.6	29.0	11.6
3	Estonia	51.5	n/a	n/a
4	Finland	46.4	61.9	49.1
5	France	49.6	56.3	53.5
6	Germany	52.5	62.8	61.5
7	Greece	38.0	15.3	65.1
8	Hungary	16.2	29.7	22.4
9	Latvia	16.3	35.8	27.9
10	Lithuania	15.8	51.4	21.7
11	Luxembourg	42.6	76.4	44.3
12	The Netherlands	36.0	77.8	41.0
13	Poland	22.7	56.9	26.2
14	Romania	16.3	24.0	24.9
15	Sweden	26.0	43.5	26.0
	Mean	**30.8**	**46.1**	**36.2**
	Minimum	**10.6**	**15.3**	**11.6**
	Maximum	**52.5**	**77.8**	**65.1**
	Standard Deviation	**14.5**	**19.4**	**15.7**
	OECD Average	**34.1**	**45.2**	**38.6**

- Digital Financial Literacy vs. Digital Service Use

The mean proportion of adults who meet the minimum digital financial literacy score across selected countries in Europe is 30.8%, while on average 46.1% of adults actively use online financial services. It suggests that a substantial part of the adult population is already engaging in digital financial activities without possessing adequate digital literacy, potentially exposing themselves to risks.

For instance, in Cyprus, only 10.6% of adults have sufficient digital financial literacy, yet 29% use online financial services. In Hungary, only 16.2% meet the literacy threshold, compared to the 29.7% who use digital financial services.

These discrepancies point to a significant digital literacy gap, whereby a large proportion of digital financial users lack the necessary skills and knowledge to manage those services safely and effectively.

This pattern is also observable in the OECD average. While only 34.1% of adults meet the minimum target level of digital financial literacy, 45.2% are managing their finances online.

- Adequate Digital Financial Literacy among Digital Financial Users

A more nuanced indicator is the percentage of digitally active adults who also meet the target digital financial literacy score. On average, only 36.2% of digital finance users reach this threshold, which is slightly below the OECD average of 38.6%.

For instance, in Germany, the alignment between usage and literacy is relatively strong, with 61.5% of users meeting the literacy benchmark. In Cyprus, this figure drops just to 11.6%,

meaning that nearly 90% of users operate with insufficient literacy, potentially placing them in a vulnerable position. In Hungary, only 22.4% of digital service users meet the literacy minimum.

These findings further support the hypothesis that the use of digital services has outpaced digital financial literacy. This could lead to digital financial exclusion, vulnerability to fraud, or misinformed decision-making.

Variability Across Countries

There is substantial cross-country variability in digital financial literacy and usage within Europe, as reflected in the standard deviation values. The standard deviation of the proportion of adults reaching the minimum digital financial literacy threshold is 14.5 percentage points, indicating notable differences across countries. This variability is even more pronounced in the case of digital finance service usage, with a standard deviation of 19.4 percentage points. Among individuals who use online financial products and services, the standard deviation of those achieving adequate digital financial literacy is 15.7 percentage points, further underscoring the uneven distribution of digital financial competencies across European populations.

A closer examination of the data reveals that countries with higher income levels and more advanced digital infrastructures—such as the Netherlands, Luxembourg, Germany, Finland, and France — tend to perform better in both digital finance usage and the alignment with digital financial literacy. In contrast, lower-income or less digitally developed countries, including Cyprus, Hungary and Romania, demonstrate larger gaps between the extent of digital finance service usage and the population's digital financial preparedness. An especially noteworthy case is Greece, where only 15.3% of adults use digital financial products and services. However, a relatively high share of these users (65.1%) meets the minimum digital financial literacy threshold. Furthermore, the overall proportion of adults achieving adequate digital financial literacy in Greece is 38.0%, which is above the sample average of 30.8%.

Correlation Analysis Between Digital Financial Literacy and Selected Socio-Demographic Factors

To explore the relationships between digital financial literacy and selected socio-demographic variables, a **Pearson correlation analysis** was conducted. The variables examined included Gender, Age, Educational attainment, Income level, and Size of settlement.

The *Pearson correlation coefficient (r)* was employed to measure the strength and direction of the linear relationship between variables, with values ranging from –1 (indicating a perfect negative correlation) to +1 (indicating a perfect positive correlation). Positive values imply that the variables increase together, while negative values imply an inverse relationship. Values close to zero imply a negligible or non-existent linear correlation.

To assess the statistical significance of the observed correlations, both *p-values* and *t-values* were calculated. The *p-value* represents the probability that the observed correlation occurred by chance. In line with conventional statistical standards, a p-value below 0.05 was considered statistically significant.

The *t-value* serves as a test statistic to evaluate the null hypothesis, which posits that no linear relationship exists between the variables ($r = 0$). The t-value is derived from both the sample size and the magnitude of the correlation. A *higher absolute t-value* indicates a stronger deviation from the null hypothesis, suggesting that the correlation is statistically meaningful. Conversely, a *lower t-value* implies insufficient evidence to reject the null hypothesis, indicating that the observed relationship may be the result of random variation within the sample.

In summary, while the *correlation coefficient (r)* quantifies the relationship between variables, the *t-value* and *p-value* jointly determine how reliable and generalizable the findings are in a broader population context.

The results of the Pearson correlation analysis are presented in Table 3 below.

Table 3: *Digital Financial Literacy and Selected Socio-Demographic Factors*
Source: *Author's calculations based on OECD INFE (2023) data*

No.	Factor	Pearson's r	Interpretation of r	Standard Error	t-value	Significance (p)	Significance Interpretation
1	Gender	-0.106	Very weak negative correlation	0.180	-0.563	0.578	Not statistically significant
2	Age	-0.081	Very weak negative correlation	0.162	-0.531	0.598	Not statistically significant
3	Educational attainment	0.579	Moderate to strong positive correlation	0.098	4.652	< 0.001	Statistically significant
4	Income level	0.479	Moderate positive correlation	0.109	3.583	< 0.001	Statistically significant
5	Size of settlement	0.222	Weak positive correlation	0.150	1.441	0.157	Not statistically significant

The analysis revealed statistically significant positive correlations between digital financial literacy and two variables: Educational attainment ($r = 0.579$, $p < 0.001$) and Income level ($r = 0.479$, $p < 0.001$). These findings indicate that individuals with higher levels of educational attainment and higher income tend to exhibit higher levels of digital financial literacy.

By contrast, the variables Gender ($r = -0.106$, $p = 0.578$), Age ($r = -0.081$, $p = 0.598$), and Size of settlement ($r = 0.222$, $p = 0.157$) did not show statistically significant correlations with digital financial literacy. Although the correlation between size of settlement and digital financial literacy was positive, it was not strong enough to reach the threshold for significance.

Overall, the findings suggest that Educational attainment and Income level are important predictors of digital financial literacy, while other demographic variables examined do not appear to play a significant role in this context.

Analysis of Variance (ANOVA)

To further investigate the observed relationships between digital financial literacy and certain socio-demographic variables, a One-Way Analysis of Variance (ANOVA) was conducted. The aim was to determine whether digital financial literacy scores differ significantly across five socio-demographic variables: Gender, Age, Educational attainment, Income level, and Size of settlement. The results of the ANOVA are summarized in Table 4.

Table 4: *ANOVA Results for the Relationship between Digital Financial Literacy and Socio-Demographic Variables*

Source: *Author's calculations based on OECD/INFE (2023) data*

ANOVA Table							
			Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Point * Gender	Between Groups	(Combined)	17.633	1	17.633	0.317	0.578
	Within Groups	With fewer than three groups, linearity measures for Point * Gender cannot be computed.	1558.533	28	55.662		
	Total		1576.167	29			
Point * Age	Between Groups	(Combined)	142.178	2	71.089	0.831	0.442
		Linearity	24.3	1	24.3	0.284	0.597
		Deviation from Linearity	117.878	1	117.878	1.379	0.247
	Within Groups		3591.067	42	85.502		
	Total		3733.244	44			
Point * Education	Between Groups	(Combined)	1274.133	2	637.067	10.82	<,001
		Linearity	1254.533	1	1254.533	21.31	<,001
		Deviation from Linearity	19.6	1	19.6	0.333	0.567
	Within Groups		2473.067	42	58,883		
	Total		3747.2	44			
Point * Income	Between Groups	(Combined)	716.933	2	358.467	6.342	0.004
		Linearity	710.533	1	710.533	12.57	<.001
		Deviation from Linearity	6.4	1	6.4	0.113	0.738
	Within Groups		2373.867	42	56.521		
	Total		3090.8	44			
Point * Settlement	Between Groups	(Combined)	108.333	2	54.167	1.015	0.372
		Linearity	108.036	1	108.036	2.024	0.163
		Deviation from Linearity	0.298	1	0.298	0.006	0.941
	Within Groups		2081.286	39	53.366		
	Total		2189.619	41			

Note:

- *Sum of Squares* reflects the variability between and within groups.
- *df* (degrees of freedom) indicates the number of independent values that can vary.
- *Mean Square* is calculated by dividing the sum of squares by the corresponding degrees of freedom.
- *F* is the test statistic used to determine whether group means are significantly different.
- *Sig.* (p-value) indicates the significance level of the test. A p-value below 0.05 denotes statistical significance.

The ANOVA analysis revealed both statistically *significant* and *non-significant* differences in digital financial literacy scores and the socio-demographic variables.

Statistically significant differences were identified in digital financial literacy scores based on participants' Educational attainment and Income level.

- Educational attainment: The ANOVA revealed a significant effect of educational attainment on digital financial literacy scores ($F(3, N) = 10.819$, $p < 0.001$), with post hoc comparisons indicating variation across the different educational categories. Furthermore, a significant linear trend was observed ($F = 21.306$, $p < 0.001$), suggesting that higher levels of education are systematically associated with increased digital financial literacy.
- Income level**:** A similar pattern emerged for income, with a statistically significant effect ($F = 6.342$, $p = 0.004$). A strong linear trend was present ($F = 12.571$, $p < 0.001$), indicating that higher income levels correspond with higher digital financial literacy scores.

Conversely, no statistically significant differences in digital financial literacy scores were found with respect to Gender, Age and Size of settlement:

- Gender**:** $F = 0.317$, $p = 0.578$
- Age**:** $F = 0.831$, $p = 0.442$
- Size of settlement: $F = 1.015$, $p = 0.372$

These findings suggest that, within this sample, Educational attainment and Income level are key socio-demographic factors influencing digital financial literacy. In contrast, Gender, Age, or Size of settlement do not appear to have a statistically significant impact on the outcome variable.

- Measures of Association

The strength of **association between digital financial literacy scores and the categorical socio-demographic variables** was further examined using *Eta* and *Eta-squared* coefficients, as shown in Table 5, including *R and R-squared*.

Eta values indicate the magnitude of the relationship, while Eta-squared represents the proportion of variance in the metric variable (digital financial literacy scores) that can be explained by the categorical grouping variables. Values closer to 1 indicate stronger effects. R and R-squared are also reported to reflect the strength and explanatory power of linear relationships between variables.

Table 5: *Measures of Association (Eta) Indicates*
Source: *Author's calculations using OECD/INE (2023) data*

	R	R Squared	Eta	Eta Squared
Point * Gender	0.106	0.011		
Score * Age	0.081	0.007	0.195	0.038
Point * Education	0.579	0.335	0.583	0.340
Point * Income	0.479	0.230	0.482	0.232

Point * Settlement	0.222	0.049	0.222	0.049

The analysis revealed moderate associations between digital financial literacy and both Educational attainment (Eta = 0.583) and Income level (Eta = 0.482). The corresponding Eta-squared values — which measure explanatory power — were 0.340 and 0.232, respectively. These results suggest that approximately 34% of the variance in digital financial literacy scores can be explained by Educational attainment, and **23%** by Income level. While these values do not indicate strong associations, they approach moderate strength, highlighting the relevance of these two variables in shaping digital financial literacy. In contrast, the remaining variables (Gender, Age, and Size of settlement) showed weak associations, with Eta-squared values below 0.05, indicating limited explanatory power.

To further examine the linear relationships between digital financial literacy scores and the socio-demographic variables R and R-squared values were used. Among the variables analyzed, Educational attainment showed the strongest linear association with digital financial literacy (R = 0.579), accounting for approximately 33.5% of the variance in scores ($R^2 = 0.335$). Income level also demonstrated a moderate linear relationship (R = 0.479; $R^2 = 0.230$), indicating that higher income levels are associated with higher literacy scores. In contrast, the linear associations between digital financial literacy and Gender, Age, and Size of settlement were weak or negligible, with R^2 values below 0.05, indicating minimal explanatory power.

These findings reinforce the conclusion that Educational attainment and Income level are the most influential socio-demographic factors in explaining variations in digital financial literacy.

Overall, the results provide partial support for Hypothesis 2 (H2), which posits that digital financial literacy is significantly influenced by key socio-demographic factors in the selected European countries. Specifically, the statistical analyses support sub-hypotheses **H2c** and **H2d**, whereas H2b, and H2e are not confirmed.

Conclusions

The statistical analysis of digital financial literacy among adults in 15 European countries reveals several key findings.

The overall level of digital financial literacy among adults in the examined European countries is relatively low and can be considered insufficient.

Of the socio-demographic variables studied, Educational attainment and Income level emerged as significant predictors of digital financial literacy. At the same time, Gender, Age, and Size of settlement showed no statistically significant influence.

Considering these findings, Hypothesis H1 was supported, confirming that digital financial literacy is insufficient and not uniformly distributed across the adult population in the 15 European countries. However, Hypothesis H2 was only partially supported, as not all the socio-demographic factors examined showed a significant effect.

Given the scope and methodology of the referenced survey — which employed a standardized and internationally validated approach with representative samples of at least 1,000 respondents per country — the results can be considered robust. Therefore, the conclusions drawn from this analysis may be reasonably generalized to the broader adult populations of the 15 European countries.

Prospects for Further Research

Several avenues may be pursued in future research. First, the scope of the analysis could be expanded both temporally and geographically. Comparing the current findings with those of earlier surveys could provide valuable insights into long-term trends. Additionally, expanding the sample to include more countries — or potentially all OECD member states — would enhance the comprehensiveness of the study. Moreover, future studies could examine the relationship between digital financial literacy and broader socio-economic indicators such as GDP per capita and internet penetration. Finally, collecting and evaluating initiatives aimed at improving digital financial literacy, identifying best practices, and formulating policy recommendations would significantly enhance the practical relevance and impact of the research.

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The impact of digital financial infrastructure on regional economic development and SME financing

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Abstract

Driven by globalization and the rapid expansion of the Internet, mobile payments have transformed the financial environment. Traditional economies are influenced by these shifts. In addition to boosting economic growth in a variety of countries, the establishment and expansion of digital financial infrastructure have facilitated globalization and economic relations. The growth and extension of digital financial infrastructure have substantially enhanced economic development, diversity and potential. However, it has also generated problems, particularly in less developed regions where infrastructure issues and slow growth have caused local economies to lag behind, exacerbating economic disparity among the regions. Many small and medium-sized enterprises around the world face high interest rates and financing concerns, and the uncertainty surrounding development has forced many commercial banks to tighten their lending conditions. One reason for the lack of a complete system is the flawed finance guarantee mechanism, which means big banks are reluctant to lend to small enterprises. The rise of digital financial infrastructure, particularly the acceptance of digital currencies, affects the funding of small and medium-sized enterprises. The rapid expansion of Internet banking and peer-to-peer lending platforms has allowed the financial services sector to provide a wider range of services to small and medium-sized enterprises. Big data and model testing have made peer-to-peer lending easier for these enterprises, enabling commercial banks to fund them more quickly and effectively. In light of these issues, this study will explore the impact of digital financial infrastructure on regional development, with a particular focus on the financing of small and medium-sized enterprises. It will demonstrate how the creation of digital financial infrastructure improves regional economic development, financial inclusion, transaction costs, cross-border trade, financial innovation, and the financing of small and medium-sized enterprises.

Keywords: Digital Financial Infrastructure Development, Regional Economic Development, SME Financing

JEL classification: R11

Introduction

Background Information

As a rapidly evolving technology sector, digital financial infrastructure has become a critical driver and enabler of economic growth across many regions. Digital financial infrastructure refers to the set of platforms, systems, and technologies that facilitate the digitization of financial services

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(Neves, Oliveira et al. 2023). These infrastructures encompass various regulatory frameworks, policy support, and both hardware and software facilities. The primary elements include:

- Digital payment systems, such as digital wallets, mobile payments, bank transfers, and other payment instruments, are essential components of the digital financial infrastructure. These systems support international cross-border transactions and guarantee secure and efficient money transfers.
- Platforms for the exchange and transmission of financial data and information are known as financial data exchange platforms. (Sayogo, Pardo et al. 2014) Financial organizations can exchange information and deliver more effective and convenient financial services by utilizing these platforms. For example, such platforms support fund clearing and interbank settlements.
- Identity identification systems are vital for ensuring the security of user identity in the digital financial ecosystem. Through the use of biometrics, digital certificates, and two-factor authentication, these systems safeguard financial transactions and protect consumer privacy (Vinayagam and Dilip 2024).
- Blockchain technology is gaining traction in digital finance, especially in the areas of digital currency, cross-border payments, and decentralized finance (DeFi). By using decentralized distributed ledger technology, blockchain reduces reliance on traditional financial intermediaries and enhances security and transparency. (Tripathi, Ahad et al. 2023)
- Big Data and Artificial Intelligence technologies support financial institutions in credit evaluation and decision-making by analyzing large volumes of transactional data. (Bhat, AlQahtani et al. 2023) AI also plays a critical role in automating services, managing risks, and performing credit assessments, etc.
- Cloud computing platforms offer scalable and cost-effective infrastructure for storing and processing financial data. These platforms enhance operational efficiency by providing flexible computing resources tailored to digital financial services.
- Financial regulatory technology (RegTech) helps financial regulators address emerging risks associated with digital finance. By employing AI, machine learning, and other advanced tools, RegTech enables real-time monitoring, compliance verification, and risk alerting, thereby increasing regulatory effectiveness.

In conclusion, digital financial infrastructure is an integrated system that encompasses payment, data, regulation, security, and other areas. It is multi-layered, cross-disciplinary, and holistic in nature—far more than a mere aggregation of tools and technologies. It encourages the innovation and modernization of the global financial system while supporting the digital economy.

Furthermore, there is a close relationship between digital financial infrastructure and regional economic development. In addition to being the fundamental backbone of contemporary economic activity, digital financial infrastructure plays a significant role in fostering regional economic expansion and boosting competitiveness (Zhang, Wang et al. 2024). The expansion of regional economies has increasingly demonstrated a pattern of reliance on digital financial platforms and infrastructure due to the rapid development of digital technology. This connection is noticeable in several respects. First, by improving access to financial services within an area, digital financial infrastructure directly contributes economic variety and vibrancyIn traditional economies—especially in remote or underdeveloped regions—access to financial services is often limited by geography and resource constraints. However, the spread of digital financial tools such as online financing, digital banking and mobile payments means that businesses and individuals can now more easily access the financial services they require. This has made regional economies more dynamic (Song, Li et al. 2020). Digital payment platforms, for instance, can help consumers

and small businesses overcome the limitations of the conventional banking system and facilitate transaction liquidity, boosting regional market competitiveness and corporate profitability. The second benefit of the digital financial infrastructure is that it lowers transaction costs, which is crucial for regional economic development (Yang, Lin et al. 2024). Interregional financial flows typically incur high transaction costs. This is particularly the case for cross-border business and financial transactions, where traditional payment methods and fund transfers are often complicated and expensive. However, by offering inexpensive payment and fund transfer channels, digital financial infrastructures drastically minimize these transaction costs and enable faster and less expensive money transfers within regions. This cost-efficiency enables businesses to increase the scope of their operations and the range of services they provide, which also boosts the competitiveness of the local economy.

The expansion of digital financial infrastructure has facilitated financial inclusion in regional economies. It has made it possible for more low-income individuals and micro and small businesses to engage in economic activity, especially in areas with limited access to traditional financial services (Johri, Asif et al. 2024). Financial services are now accessible to everyone through channels such as peer-to-peer lending platforms, digital money, and mobile payments, thereby promoting equitable growth and wider participation in local economies. Digital financial infrastructure can provide small and medium-sized enterprises (SMEs) with flexible access to financing, enabling them to overcome funding shortages and boost innovation and productivity. Lastly, while promoting regional economic growth, digital financial infrastructure also makes international collaboration and cross-border trade easier. As more regions undergo digital transformation, long-standing obstacles to global trade are being removed. Using digital currencies and blockchain technology makes it much easier and more transparent to send money across borders. It has also reduced the financial risks and problems associated with doing business across borders, fostering economic cooperation and interaction between regions. This is yet another reason why it is impossible to ignore the contribution that digital financial infrastructure makes to regional economic growth. In addition to providing regional economies with more effective financial services, it also lowers transaction costs, encourages financial inclusion, and makes cross-border commerce and economic cooperation easier. A robust digital financial infrastructure is essential for the sustainable growth of regional economies in the current era of economic globalization and digital transformation.

Research Content

This study will focus on the impact of developing digital financial infrastructure on regional economies, with particular emphasis on its role in the financing of SMEs. It will also explore strategies for constructing a reasonable digital financial infrastructure that supports enterprise financing and economic development.

The construction of digital financial infrastructure is a critical element in modernizing financial services and significantly affects the sound growth of the local economy. The development of a superior, more practical, and affordable payment system, data exchange platform, and information security guarantee system would benefit local businesses, improve market liquidity, and encourage the efficient use of resources (Ye, Zhou et al. 2022). The development of digital financial infrastructure in the regional economy allows information and capital to transcend geographic boundaries, facilitating regional collaboration and resource sharing. Therefore, this study also aims to analyze how the development of digital financial infrastructure shapes local economic performance.

SMEs are vital to the local economy, but because of a lack of financial sources, they frequently struggle to raise the funds they require. Digital financial infrastructure provides SMEs with additional funding options, particularly through the increased popularity of digital payment platforms, peer-to-peer (P2P) lending platforms, and digital currency financing channels (A. Basha, Elgammal et al. 2021). Therefore, analyzing the effects and function of the development of digital financial infrastructure in financing SMEs is therefore essential, as it gives SMEs more financial freedom in addition to expanding their funding options. Accordingly, the main goal of this study is to examine how the growth of digital financial infrastructure affects regional development, particularly the financing of SMEs. The study will consider how different regions have varying levels of Internet access, modern payment methods, and types of digital currency. Additionally, it will evaluate how the advancement of digital financial infrastructure contributes to and influences regional economic growth.

Literature Review

A review of the literature and research indicates that numerous scholars have examined the influence of digital financial infrastructure on economic development. However, the majority of existing studies tend to focus on how digital finance and digital currency can stimulate economic growth. There has been relatively insufficient research into how digital financial infrastructure can promote regional economic growth, particularly with regard to SME financing. This study will examine current research and successful case studies to demonstrate how digital financial infrastructure can help small and medium-sized businesses overcome the problems with the existing financial system and discover alternative funding opportunities through technological innovations such as peer-to-peer lending and big data credit assessment. More broadly, the study will look at how the growth of digital financial infrastructure affects regional economic growth, including its role in providing access to finance, reducing transaction costs, accelerating cross-border trade, fostering new financial practices, and facilitating SME loan access.

Advancement of digital financial infrastructure

The evolution of digital financial infrastructure is unfolding parallel with the ongoing information technology revolution and the spread of globalization (He, Mu et al. 2024). Rapid advancements in Internet technologies, mobile communication, cloud computing, big data, and blockchain have profoundly reshaped the traditional financial service paradigm, leading to the emergence and swift expansion of digital financial infrastructure. Digital financial infrastructure has become a crucial component of the digital economy and a significant driver of global economic modernization that enhances the accessibility and efficiency of financial services (Xia, Baghaie et al. 2024).

The concept of digital financial infrastructure can be delineated over multiple dimensions. It encompasses payment systems, financial information processing platforms, financial data interchange and storage systems, digital identity identification, and information security assurance technologies (Ratna, Saide et al. 2024). Digital financial infrastructure is merely a collection of different technologies; it represents a multi-tiered, interconnected system that transcends the limitations of the current financial system. It facilitates the flow of money and optimizes the use of resources by offering quick, inexpensive, transparent, and secure financial services. The advancement of digital payment systems is a crucial element of digital financial infrastructure. Due to the proliferation of smartphones and advancements in Internet infrastructure, mobile payments have emerged as a dominant mode of daily financial transactions in numerous countries worldwide. In China, India, and Southeast Asia, for example, the popularity of mobile platforms such as Alipay,

WeChat Pay, and Apple Pay have become extremely popular, significantly advancing the development of digital financial infrastructure. These payment methods facilitate cross-border transactions, internet commerce, financial services, and other activities, prompting a surge in financial technology (FinTech) advancements worldwide (Ayade, Ayade, 2024). Technological advancements in the financial sector have enabled the development of digital financial platforms, particularly for the exchange, storage, and processing of financial data. Big data technology enables financial institutions to collect, process, and analyse large volumes of data from consumers and marketplaces in real time, improving credit risk assessment and enabling personalized service provision (Specialist, n.d.). The integration of Artificial Intelligence (AI) and machine learning has further transformed digital financial services, enabling higher levels of automation and intelligent decision-making. It has also made it easier to customize and adapt financial products for different markets. This is a significant advancement in the evolution of digital financial infrastructure. Simultaneously, the development of digital financial infrastructure is increasingly intertwined with blockchain technology. As a decentralized distributed ledger, blockchain technology plays a transformative role in digital currencies (such as Bitcoin and Ethereum) and financial transactions (Javaid, Haleem et al. 2022). Blockchain technology makes financial transactions safer and reduces intermediary costs by making data more open and immutable. It also accelerates innovation in cross-border payments, digital asset trading, and other global financial activities. Furthermore, the use of cloud computing significantly improved the scalability and adaptability of digital financial infrastructure (Khayer, Talukder et al. 2020). Cloud platforms enable financial organizations to utilize robust computing and storage capabilities at reduced costs, facilitating the swift deployment and worldwide scaling of financial services. In developing countries, cloud computing has mitigated the deficiencies of the traditional banking infrastructure, offering enhanced and widespread access to financial services.

Progress in digital financial infrastructure has been a remarkable success around the world. It has made financial services more accessible and enabled the digital transformation of economic activity. As technology advances and the range of applications broadens, digital financial infrastructure will play an increasingly significant role in the global economy. The development of digital financial infrastructure is progressing from mature markets to emerging and developing countries, offering significant momentum for the equitable advancement of the global economy (Haoran, Wenlong et al. 2024). Understanding the evolution of digital financial infrastructure and its implementation in various regions is of both theoretical and practical importance, particularly for assessing its influence on regional economic growth, and its potential for funding SMEs.

The Role of SMEs in Regional Economic Development

SMEs are integral to regional economic development. They play a fundamental role in the economy, fostering innovation and employment while making a significant contribution to social stability, regional economic diversification, and global competitiveness. Despite regional variations in economic conditions and developmental stages, the global impact of SMEs is undeniable.

In numerous countries, particularly developing ones, SMEs have become a major source of employment and a key driver of labour market integration and unemployment reduction. According to the World Bank around 90% of firms worldwide are SMEs, which has a significant influence on the job market in various countries and regions. In Europe and the United States, SMEs account for approximately 60% of total employment; however, in certain emerging economies in Africa and Asia, this percentage may be even higher (Ongbali, Omotehinse et al. 2024). Consequently,

SMEs not only facilitate labour absorption but also contribute to sustained socio-economic growth by developing the talents and professional attributes of workers. Secondly, SMEs are essential in fostering innovation and competitiveness within regional economies. Unlike large firms, SMEs are more flexible and innovative, enabling them to react swiftly to market demand fluctuations and secure competitive advantages in certain industries or locations. SMEs in high-tech, service, and creative sectors frequently serve as catalysts for technological innovation and new product development. SMEs are central to the growth of numerous technology start-ups and digital platforms, particularly in technology hubs like Silicon Valley. Through autonomous innovation and swift market adaptation, they not only boost the regional industrial chain but also foster economic diversification and bolster the region's global competitiveness. Moreover, SMEs play a crucial role in the diversification of regional economies. In numerous developing countries and growing markets, economic progress has historically relied on a single industry, such as agriculture or resource extraction. The creation and expansion of SMEs, however, contributes to the dismantling of this uniform industrial framework. By offering a variety of goods and services, SMEs can foster synergistic growth across multiple industries and improve the overall competitiveness of regional economies. SMEs in some Southeast Asian and Latin American countries are shifting from manufacturing to services and from traditional to modern farming technologies (Abe 2009). This makes the regional economy less dependent on a single industry and more resistant to risks. As globalization intensifies, cross-border commerce and investment are increasingly emerging as significant catalysts for economic growth. Due to their adaptable operational frameworks and inventive potential, small and medium-sized enterprises can penetrate global markets sooner, thereby significantly contributing to the economic development of their regions. In growing markets like Asia, Africa, and Latin America, SMEs have consistently increased their participation in the global supply chain, contributing positively to global commerce, bolstering regional economic collaboration, and increasing foreign trade export capabilities.

In conclusion, SMEs play a variety of roles in regional economic development. As well as being significant contributors to job creation and economic growth, they also act as catalysts for globalization, industrial diversification, and regional innovation. To fulfil their potential, relevant governments and policymakers must create a favorable business environment for the expansion of SMEs by adopting appropriate policy measures, such as financial support, tax incentives, and innovation incentives. By encouraging the sustainable growth of SMEs, they can further contribute to the stability and prosperity of the regional economy and raise the region's overall competitiveness.

The role of digital finance in facilitating the financing of SMEs

Excessive interest rates and difficulty obtaining financing are two major problems for SMEs worldwide. Due to factors such as insufficient collateral and imperfect credit history, SMEs are frequently excluded from the formal financing systems or unable to obtain support from traditional financial institutions, particularly in developing countries and emerging economies (Wang 2016). Consequently, inadequate funding is one of the obstacles impeding the growth of SMEs. SMEs are vital for economic growth, innovation, and job creation. However, due to their perceived high risk and small size, traditional banks often struggle to provide them with sufficient financial support.

The history and importance of financing SMEs

The origins of SME financing can be traced back to the Industrial Revolution, when traditional banks began providing financial assistance to small businesses, thereby establishing the framework

for the current economic system (Cull, Davis et al. 2006). However, SMEs have encountered rising funding thresholds because of the transformation of the banking sector, particularly the increasingly strict rules of commercial banks regarding capital allocation and risk control. Typically, commercial banks require that businesses submit comprehensive financial accounts, asset guarantees, and other documents – a process that is both expensive and time-consuming. The primary goal of these stringent documentation requirements on the part of banks is to reduce loan default risk (Danisman and Demirel 2019). As SMEs often suffer from limited financial transparency and insufficient asset reserves, banks must undertake thorough and cautious evaluations to assess their creditworthiness and operational risk before extending loans.

However, SMEs typically do not benefit from this conventional funding strategy. High loan interest rates and collateral requirements can have a severe financial impact on businesses, especially during periods of market volatility or economic downturn. SMEs sometimes struggle to pay exorbitant finance costs, which impact their growth and operations. This underscores the pressing need for SMEs to identify more cost-effective and accessible financial resources.

The role of digital financial infrastructure in facilitating SME financing

Traditional approaches to SME financing are undergoing significant transformation due to the rise of digital financial infrastructure. This evolution includes the use of technologies such as big data analytics, digital payment systems, and peer-to-peer lending platforms. By eliminating the complicated paperwork and high interest rates associated with traditional bank loans, digital financial platforms have simplified the loan process for small businesses and provided them with more options. The emergence of digital currencies and decentralized finance (DeFi) enables SMEs to diversify their financing sources reducing their dependency on banks and intermediaries while improving financing flexibility and efficiency (Chen and Bellavitis 2020). One notable advancement is the use of P2P lending systems, which provide SMEs with more direct and accessible funding. By digitally connecting investors and borrowers directly, these platforms eliminate the need for traditional financial institutions to act as intermediaries. P2P lending platforms can typically offer lower interest rates and more flexible loan terms than traditional bank loans. In addition to bypassing the unduly strict vetting processes of traditional banks for borrowers, these platforms use big data and artificial intelligence technologies to evaluate the creditworthiness of borrowing organizations. This results in faster, more transparent, and cost-effective financing for SMEs.

The application of big data analytics and advanced credit assessment technologies has significantly enhanced the ability of digital financial platforms to evaluate the creditworthiness of SMEs. These platforms collect and analyse a large amount of unstructured data (such as transaction records, social media activity, etc.) to create credit evaluation models that are mor thorough than those used for traditional bank loans, which depend on financial statements and collateral (Wang, Jiang et al. 2024). This not only reduces the risk of information asymmetry but also opens up funding options for SMEs that the conventional banking system finds challenging to serve. Furthermore, blockchain technology and digital currencies improve the ease and transparency of SME funding. Businesses can bypass the traditional banking system and obtain funding directly from investors or customers by issuing digital currencies or tokens. For example, several SMEs have been able to swiftly raise the money they require by making initial coin offerings (ICOs) or participating in tokenized asset financing. (Fisch 2019). This not only diversifies their financing options but also reduces intermediary fees and enhances the efficiency of capital allocation.

Contributions of commercial banks to the development of digital financial infrastructure

Commercial banks have also begun to adjust to new financing requirements and offer more creative financing services for SMEs as part of the broader process of developing digital financial infrastructure. They have simplified the loan application, approval, and disbursement processes by introducing digital lending solutions in collaboration with fintech firms. These banks usually use big data technology to evaluate SMEs' creditworthiness, make swift loan approval decisions, and provide flexible repayment plans throughout the loan process. This digitalised lending approach not only increases the operational effectiveness of banks, but it also enables SMEs to obtain funding more swiftly.

Enhancement of the financial guarantee system

While digital finance has expanded the financing options available to SMEs, a reliable financing guarantee system is still required to facilitate the process. By implementing guarantee arrangements, risk pooling, and policy support, the government and financial institutions can reinforce the protection of SME finance (Bai, Ba et al. 2020). For example, by creating guarantee funds and loan risk compensation procedures, the government can assist SMEs in obtaining additional financial support on digital financial platforms. Furthermore, banks and other financial organizations should conduct more research into the financing requirements of SMEs and offer tailored financial products to meet their various financing needs.

Finally, the growth of digital financial infrastructure, particularly the use of technologies such as digital currencies, big data analytics, and peer-to-peer lending platforms, is having a significant impact on how small businesses access funding. In addition to solving the problems of costly and difficult financing for SMEs, digital finance is breathing new life into the sustainable growth of the global economy by offering more flexible and affordable financing channels.

The Kenyan Case study: M-Pesa

The development of M-Pesa, a well-known and significant digital financial platform in Kenya, has not only disrupted established financial services but also offers valuable insights to other countries and regions. (Ndung'u 2018). M-Pesa is a mobile payment and financial services platform that uses mobile communication technology to provide easy-to-use financial tools to the unbanked or those excluded from traditional financial institutions. M-Pesa has transformed the way the regional economy and financial system function and addressed the issue of many individuals lacking access to financial services, particularly in developing countries. M-Pesa's accessibility and popularity are its main advantages. By collaborating with telecom companies, M-Pesa leverages Kenya's extensive mobile network, which many people rely on instead of traditional bank accounts, to enable users to easily perform basic financial transactions such as money transfers, bill payments, deposits, and withdrawals (FasterCapital., n.d. 2024). In addition to being a payment instrument, M-Pesa has evolved to offer a variety of financial services such as overseas remittances, insurance, and microfinance, all of which have significantly improved financial inclusion in Kenyan society. M-Pesa serves as a vital financial instrument for the unbanked effectively bridging the gap between traditional financial institutions and marginalized populations.

From an economic standpoint, M-Pesa has significantly influenced Kenya's growth. Firstly M-Pesa reduces transaction costs while providing SMEs with straightforward payment and settlement options. Secondly, it has promoted regional economic integration and increased the liquidity of Kenya's domestic and international trade. Furthermore, by digitizing traditional

banking services, M-Pesa has encouraged financial inclusion within the country, allowing a greater number of low-income individuals to actively participate in economic activity. The success of M-Pesa has prompted other developing countries and regions to examine the viability of digital financial services (Tay, Tai et al. 2022). M-Pesa's adaptable business strategy and technological innovation are key factors in its success. It removes the constraints of conventional banking and financial service models and establishes a new digital financial ecosystem by working with a variety of partners, including financial institutions, retailers, and telecommunications firms. By boosting market competitiveness, capital liquidity, and the local economy, this ecosystem's operation supports the long-term expansion of the regional economy.

Conclusion

This review has focused on the construction and evolution of digital financial infrastructure and its application in the financing of SMEs. It has also examined the role of digital finance in the local economy and how cutting-edge technological platforms can be used to support the financing needs of SMEs. Examining pertinent examples and literature allows us to draw the following conclusions. First, the growth of digital financial infrastructure has significantly boosted the efficiency and popularity of international financial services. Modernization of payment system, advancements in Internet technology, and the use of cutting-edge technologies such as blockchain and big data have not only increased the security and accessibility of financial services but also decreased transaction costs and boosted local economies. This shift has further promoted financial inclusion by improving the economic engagement of low-income groups and remote areas.

Second, the traditional financial system has historically presented significant barriers and expenses for SMEs, despite their status as a major force in the regional economy. SMEs now have more affordable and flexible financing options thanks to the rise in digital finance, particularly the use of P2P lending platforms and digital currencies. These innovations have improved SMEs' market accessibility and allowed them to secure capital via non-traditional channels. Big data and artificial intelligence technologies have also increased the accuracy of credit evaluation in digital finance, which has made it simpler for SMEs to obtain funding.

Lastly, the success of the digital finance platform M-Pesa illustrates how digital finance is not only a product of technological innovation, but also a powerful tool for transforming traditional financial systems. By making mobile payments and financial services widely available, M-Pesa has helped many unbanked individuals with their financial needs, fostering economic growth and financial inclusion. The successful example of M-Pesa in Kenya demonstrates the potential of digital financial infrastructure for regional economic development and serves as a key benchmark for other developing countries.

Furthermore, it is evident that the construction and development of digital financial infrastructure is crucial for improving the effectiveness of financial services and reducing transaction costs. It also increases the number of financing options available to SMEs and encourages the internationalization and diversification of local economies. As technological innovation continues to evolve, digital finance will play a significant role in driving economic growth on a global scale.

Methodology

Data Sources and Variable Descriptions

This study investigates the impact of digital financial infrastructure on regional economic development and SME financing using data from six representative countries: China, the United States, Germany, India, Saudi Arabia, and Kenya. These countries were selected based on their varying levels of economic development, maturity of digital financial infrastructure, and regional influence, thereby ensuring a comprehensive analysis of diverse economic environments.

Variables and Their Definitions

1. **Digital Payment Penetration Rate (%):**
- Definition: The percentage of the population that has made or received digital payments in the past year.
- Unit: Percentage (%).
- Relevance: This variable reflects the adoption and integration of digital payment systems, which are key aspects of digital financial infrastructure. It is crucial for understanding the accessibility and utilization of financial technology.
2. **Internet Penetration Rate (%):**
- Definition: The proportion of the population with access to the internet.
- Unit: Percentage (%).
- Relevance: Internet access is a fundamental enabler of digital financial services, facilitating the use of online payment systems, e-commerce, and other digital platforms.
3. **Gross domestic product growth Rate (%):**
- Definition: The annual percentage growth rate of a country's Gross Domestic Product (GDP).
- Unit: Percentage (%).
- Relevance: It serves as a primary indicator of economic performance and allows for the assessment of regional economic development influenced by digital financial advancements.
4. **Employment Rate (%):**
- Definition: The percentage of the working-age population (15 years and over) that is employed.
- Unit: Percentage (%).
- Relevance: It highlights the health of the labor market and its interaction with economic growth and digital financial accessibility.
5. **Net National Income per Capita (USD):**
- Definition: The net income per person in a country, adjusted for population size.
- Unit: US Dollars (USD).
- Relevance: It reflects the economic well-being of individuals and their ability to access and utilize digital financial services.

These five indicators were chosen to provide a comprehensive view of economic and digital financial dynamics in different regions. Together, they provide a multidimensional view of how digital financial infrastructure contributes to regional economic growth and SME financing.

Time Frame and Country Selection

The data spans six years from 2015 to 2020. These countries were selected for their unique characteristics:

- China: A global leader in digital payment adoption, as evidenced by platforms such as Alipay and WeChat Pay (World Bank, 2022).

- United States: A mature economy with robust digital infrastructure and well-established financial systems (Pew Research Center, 2021).
- Germany: A European country with high internet penetration but more conservative digital payment adoption (Eurostat, 2021).
- India: A rapidly developing country where government-led initiatives such as Digital India are promoting financial inclusion (Choppala & Meka, 2024).
- Saudi Arabia: A high-income country that is adopting digital financial systems as part of Vision 2030 (Khan & Alhadi, 2022).
- Kenya: Known for its successful mobile payment systems (e.g., M-Pesa), which are a model for financial inclusion in developing countries (Wang et al., 2018).

These countries were selected to ensure a balanced representation in terms of economic maturity, regional diversity, and levels of digital financial adoption. Their inclusion also helps to mitigate potential biases that could arise from focusing exclusively on either developed or developing economies, thereby enhancing the generalizability of the study's findings.

Analytical Methods

Data Processing

1. Data Collection:
- Data was sourced from authoritative global databases, including the World Bank, the International Telecommunication Union (ITU), and national statistics offices (World Bank, 2022).
- Missing values were addressed using linear interpolation, ensuring continuity in the time series.

Variable Standardisation:

- All indicators were normalized as required to ensure comparability across countries and years.

2. Descriptive Statistical Analysis

Descriptive statistics were employed to provide an overview of the variables, highlighting their meaning, standard deviation, and distribution characteristics. This step provides a foundational understanding of the data before deeper analysis.

Correlation Analysis

Pearson correlation coefficients were calculated to assess the linear relationships between the variables. The analysis highlights important relationships that shape how we understand the impact of digital financial infrastructure. Pearson correlation is a widely recognized statistical tool for assessing the strength and direction of linear relationships between two continuous variables (Rodgers & Nicewander, 1988). By using this method, the study identifies nuanced interdependencies between indicators such as digital payment penetration and GDP growth.

Analysis Tools

- Microsoft Excel was used for all computations, including descriptive statistics and correlation analyses. The built-in functions and data visualization tools facilitated efficient and accurate analysis.
- Key formulas include:

$$r = \frac{\sum_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \overline{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \overline{Y})^2}}$$

Pearson Correlation Coefficient:

Explanation of Formula Components:

- Xi and Yi: Individual data points for the two variables being compared.
- $\bar{X}$ and $\bar{Y}$ Mean values of the respective variables.

Summations are used to compute the covariance and variances required for calculating r.

Pearson correlation analysis assumes linearity, absence of outliers, and interval/ratio-level data. Its applicability in this study is supported by the continuous and quantitative nature of the selected indicators (Menard, 2010).

Analytical Framework

Step 1: Descriptive Statistics

Descriptive statistics provided an initial understanding of the distribution and variability of the five key indicators across the six countries over the six-year period. The following parameters were calculated:

- Mean and standard deviation to summarize central tendency and spread.
- Minimum and maximum values to highlight data ranges.
- Distribution characteristics to detect potential outliers.

Step 2: Correlation Analysis

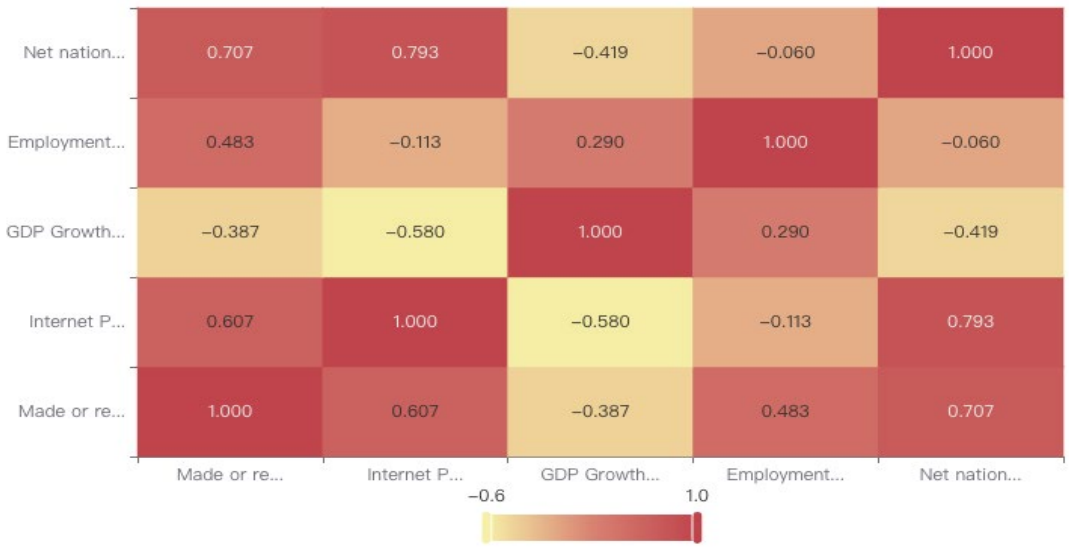

Table 1: *Correlation heat map*

Source: *Initial data were collected by authors from the World Bank (World Bank, 2022).*

The Pearson correlation coefficients were calculated for each pair of indicators. This analysis revealed key relationships, such as:

- The association between digital payment penetration and GDP growth.
- The role of internet penetration in enhancing employment rates.

Step 3: Cross-Country Comparisons

A comparative analysis was conducted to examine the heterogeneity among the six countries. Specific attention was given to:

- The relative advancement of digital financial infrastructure.
- Variations in economic development indicators.

Step 4: Interpretation of Results

Key findings were derived from statistical analyses and integrated with existing literature to provide insights into the impact of digital financial infrastructure on regional economic development and SME financing.

Results

Summary of Findings

This study explored the relationship between digital financial infrastructure and regional economic development, focusing in six countries: China, the United States, Germany, India, Saudi Arabia, and Kenya. By analysing five key indicators—digital payment penetration rate, internet penetration rate, GDP growth rate, employment rate, and net national income per capita—several significant findings emerged:

Digital Payment Penetration and Internet Penetration*:*

A strong positive correlation ($r = 0.607$, $p < 0.001$) was observed between digital payment penetration and internet penetration rates, emphasizing the role of internet accessibility in driving digital payment adoption. However, digital payment penetration showed a negative correlation with GDP growth rate ($r = -0.387$, $p < 0.05$), suggesting that other economic factors may moderate this relationship.

Internet Penetration and Income:

Internet penetration showed a strong positive correlation with net national income per capita ($r = 0.793$, $p < 0.001$), highlighting the significant role of technological infrastructure in improving individual economic well-being. In contrast, no statistically significant correlation was found between Internet penetration and the employment rate ($r = -0.113$, $p > 0.05$), suggesting a complex and possibly indirect influence on labor markets.

Economic Growth and Employment:

There was a weak positive correlation between the GDP growth rate and the employment rate ($r = 0.29$, $p < 0.1$), pointing to the possibility of modest job creation alongside economic expansion. However, the negative correlation between GDP growth and net national income per capita ($r = -0.419$, $p < 0.05$) highlights disparities in how economic growth translates into individual income gains.

These results reveal the multifaceted dynamics of digital financial infrastructure and its interplay with regional economic indicators. While technological advancements such as digital payments and internet access significantly impact economic outcomes, their influence varies depending on the context and stage of development.

	Made or received digital payments	Internet Penetration Rate	GDP Growth Rate	Employment Rate	Net national income per capita
Made or received digital payments	1(0.000***)	0.607(0.000***)	-0.387(0.020**)	0.483(0.003***)	0.707 (0.000***)
Internet Penetration Rate	0.607(0.000***)	1(0.000***)	-0.58(0.000***)	-0.113(0.510)	0.793 (0.000***)
GDP Growth Rate	-0.387(0.020**)	-0.58(0.000***)	1(0.000***)	0.29(0.086*)	-0.419 (0.011**)
Employment Rate	0.483(0.003***)	-0.113(0.510)	0.29(0.086*)	1(0.000***)	-0.06 (0.727)
Net national income per capita	0.707(0.000***)	0.793(0.000***)	-0.419(0.011**)	-0.06(0.727)	1 (0.000***)
Note: ***, **, * represent 1%, 5% and 10% significance levels, respectively.					

Table 2*: Pearson correlation analysis coefficient table*
Source: *Initial data were collected by authors from world bank (World Bank, 2022).*

Theoretical and Practical Implications

Theoretical Contributions:

This study enhances our understanding of the relationship between digital financial infrastructure and key economic outcomes by emphasizing the non-linear effects and contextual factors that influence these dynamics. It highlights the need for a multidisciplinary approach to digital financial research, integrating insights from economics, technology, and social development. The findings contribute to discussions about the role of financial inclusion in driving economic equality and sustainable development.

Practical Recommendations:

- **Policy Makers**: Governments should invest in digital infrastructure development, including providing widespread internet access and running digital literacy programs, to enhance financial inclusion and economic productivity.
- **Businesses**: Enterprises in the digital finance sector should focus on creating adaptable solutions that address regional disparities in technology adoption and economic readiness.
- **International Organizations**: Development agencies should prioritize digital finance as a tool to support the growth of SMEs and reduce regional economic disparities. Special attention should be paid to low-income and developing countries where digital financial infrastructure remains underdeveloped.

Limitations and Future Research Directions

Limitations:

- The analysis was based on data from only six countries, which limits the generalizability of the findings to different regional and economic contexts.
- The study period (2015-2020) does not capture long-term trends or the evolving role of digital financial infrastructure in the global economy.
- Correlation analysis reveals statistical relationships but does not prove causation. This restricts the possibility of drawing definitive conclusions about the mechanisms underlying observed patterns.

Future Research:

- Expanding the sample to include more countries with diverse economic and technological characteristics would provide a more comprehensive understanding of global trends.

- Extending the timeframe to include more recent developments, particularly since 2020, would provide insights into the resilience and adaptability of digital financial infrastructure in response to global challenges such as the COVID-19 pandemic.

- Incorporating variables related to government policies, such as digital payment regulations or public investment in technology, would allow us to explore the role of policy interventions in shaping digital financial ecosystems.

- Using advanced econometric methods, such as panel data analysis or structural equation modelling, could help establish causal relationships and uncover underlying mechanisms driving the observed correlations.

Addressing these limitations will enable future studies to build on this research and offer richer and more nuanced insights into the transformative potential of digital financial infrastructure.

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Online or in person? Corporate Approach in Digitalisation and Future Trends of the Fairs and Conference Market

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Abstract

This paper aims to present and analyse the digitalisation of the visitor economy in Hungary and to explore the impact of the COVID-19 pandemic on the spread of digital services in the meetings and exhibitions industry. Drawing on recent international academic research, we explore how the COVID-19 pandemic influenced the digitalisation of the global market of meetings, conferences and exhibitions in our globalised world between 2020 and 2024. The central research question investigates whether digitalisation accelerated as a result of the demand shock experienced in a specific sector of the visitor economy due to pandemic-related restrictions. Digital solutions were already present in the business conference and fairs segment. We aim to substantiate whether these tools represented a breakthrough during and after the pandemic and in the context of corporate sustainability visions. The research methodology combines an academic literature review, data analysis, and semi-structured interviews with key stakeholders in the Hungarian conference and fairs market to gain insights into digitalisation trends and future perspectives. The findings of the study show that service providers introduced digital services to overcome the barriers during the COVID-19 pandemic and maintained them after the crisis successfully. Digitalisation in the event industry contributes to the competitiveness of service providers. For future research, we propose examining the preferences of Hungarian companies regarding participation in physical versus virtual business events and exhibitions, and evaluating whether the Hungarian Meetings, Incentives, Conferences and Exhibitions (MICE) industry can meet these expectations.

Keywords: visitor economy, exhibitions and trade fairs, digitalisation, trade promotion, COVID-19, pandemic.

JEL classification: L83, L86, M31

Introduction

Tourism has been among the fastest-growing sectors of the 20th and 21st centuries, playing a pivotal role in the Gross Domestic Product (GDP) growth of numerous countries (Akash et al., 2024; Toubes & Araújo-Vila, 2022). Over the past century, it has provided a vital pathway to prosperity and development, even for nations lacking such competitive advantages as mineral resources or industrial capacity. The expansion of globalisation is inextricably linked to the growth of tourism. Technological advancements supporting globalisation have significantly contributed to the development of the tourism sector over various periods. Innovations in transportation and communication since the 19th century have fueled the steady growth of both leisure and business travel (Chlodnicki et al., 2011).

Since the latter half of the 20th century, business tourism has evolved into an independent sector with substantial multiplier effects. Alongside leisure travel, business tourism gained increasing prominence by fostering specialised commercial and marketing niches, including

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conferences, exhibitions, trade fairs, and business-to-business (B2B) meetings (Martín-Rojo & Gaspar-González, 2024).

While tourism yields numerous benefits, its adverse effects cannot be overlooked. These concerns have increasingly dominated research and professional discourse. Key concerns include the negative consequences of overtourism on local communities, rising carbon footprints, environmental degradation, and heightened health and safety risks. Furthermore, the vulnerability of communities reliant on visitor economies has prompted various joint initiatives by international tourism and sustainability organisations (Toubes & Araújo-Vila, 2022). As this article demonstrates, the COVID-19 pandemic caused significant disruption in the otherwise unbroken growth trajectory of tourism. However, it did not halt the sector's long-term expansion. International studies and statistics indicate that, following the lifting of pandemic-related restrictions, the sector rebounded swiftly and is projected to maintain its upward trend.

This research also investigates whether the Meetings, Incentives, Conferences, and Exhibitions (MICE) sector has successfully adapted to an increasingly digital landscape and whether it can competitively implement digital tools and services. We identified a significant research gap concerning *the digitalisation of the Hungarian business tourism sector*, as currently available data and surveys remain limited. To address this gap, the study assesses the digitalisation of the Hungarian MICE sector through a multi-step methodology. First, we conducted a comprehensive literature review and analysed available global databases to gain insights into the current state and future prospects of the sector. Additionally, the performance of Hungary's business tourism sector was evaluated based on existing data and industry publications. In the primary research phase, semi-structured interviews were conducted with Hungarian business tourism service providers and umbrella organisations to examine available digital services. In subsequent phases of the research, we plan to involve exhibitor and exporter companies to further deepen the analysis. Ultimately, this research aims to provide insight into successful digitalisation strategies for the Hungarian MICE sector.

Theoretical background

Significance and characteristics of the MICE sector

Global trade continued to expand between 2008-2020[2] characterised by substantial growth in the service sector alongside the global trade in goods. Since the early 2000s, digitalization has fundamentally reshaped the global flow of information and resources. The emergence of incremental innovations - including the internet, virtual and augmented reality (VR/AR), electronic payment methods, the rise of video streaming, and recently artificial intelligence - has significantly transformed segments of the service industry, notably tourism, hospitality, and the hotel industry, as well as the supporting services, conference, and business tourism. Beyond leisure tourism, the MICE sector exerts a significant multiplier effect. According to the definition introduced by the United Nations World Tourism Organisation (UNWTO)[3] in 2007, the MICE industry encompasses Meetings, Incentives, Conferences, and Exhibitions. The sector's multiplier effect is particularly noteworthy because business travelers typically demand higher-quality services and spend more during their trips. As defined by Martín-Rojo (2022, cited in Martín-Rojo & Gaspar-González, 2024), the MICE sector includes, among others, the organisation of congresses, conferences, symposia, and seminars, as well as corporate symposia, meetings, matchmaking and partner-

[2] World Trade Organisation (WTO), https://stats.wto.org/
[3] United Nations World Tourism Organisation, https://www.unwto.org/

seeking events, together with supplementary incentive programmes that accompany business events. This sector plays a crucial role not only within the tourism sector but also in facilitating international market expansion. For instance, participating in international exhibitions provides a strategic platform for business growth; trade fairs remain an essential component of international marketing and sales strategies, enabling firms to achieve diverse business objectives (Tafesse & Skallerud, 2017).

MICE Industry's Global Impact

To illustrate the economic importance of the MICE industry, this study draws on several statistical sources. The UNWTO World Tourism Barometer anticipated a full recovery to pre-pandemic levels in terms of spending and arrivals by the end of 2024[4]. Market projections from Fortune Business Insights further highlight this growth, valuing the global MICE market at USD 904.30 billion in 2023. This figure is projected to rise from USD 970.76 billion in 2024 to USD 1,932.73 billion by 2032, with Europe maintaining its position as the largest revenue-generating market[5].
To underscore the economic significance of the MICE industry, this study draws on several key statistical sources. The UNWTO World Tourism Barometer anticipates a full recovery to pre-pandemic levels in terms of spending and arrivals by the end of 2024.

To demonstrate the impact of fairs and exhibitions within the MICE industry segment, we used the database of the *Global Association of the Exhibition Industry (UFI)* as a primary source. The first impact study by UFI was completed in 2019, providing a comprehensive overview of the *"direct, indirect and induced impact"* of the exhibition sector. Regarding the direct impacts, in 2019 – in the year preceding the pandemic – exhibition organisers sold 147 million net square meters of exhibition space, generating approximately 1,253.6 billion USD in direct spending across 4.8 million exhibitors and 353 million visitors. Regionally, Europe demonstrated high capacity, attracting 1.3 million exhibitors and 112 million visitors. North America was ranked second, followed by the Asian market, with a 20.4% share of direct spending (UFI, 2020). Regarding the impact of the exhibition industry on the target countries' GDP and job creation, the industry contributed to the creation of more than 1.4 million jobs and 82.3 billion GDP output. *"Indirect impacts"*—such as event-related services and accommodation—and *"induced impacts"*—including energy and food supply chains—contributed an additional USD 201 billion to global GDP and supported over 3.4 million jobs across 180 countries (UFI, 2022).

It must be noted that there are significant differences among countries regarding the economic output and influence of exhibitions and fair industry. Established urban centers and traditional venues attract more events and visitors, compared to smaller cities or developing or regions. One reason for this may lie in the infrastructural background needed to organise a successful, high-quality international event. In conclusion, the exhibition and trade fair industry has a significant direct and indirect impact on host economies, with a strong positive influence on GDP and job creation, as well as on international competitiveness. However, the COVID-19 pandemic highlighted the inherent vulnerability of this service sector segment within a highly globalised landscape.

[4] See: https://www.unwto.org/un-tourism-world-tourism-barometer-data
[5] See: https://www.fortunebusinessinsights.com/mice-market-108653

Impacts of the COVID-19 pandemic on the MICE sector

Following the emergence of SARS-COV-2 at the end of 2019, the world's health institutions struggled to provide effective treatments or contain the virus's rapid spread (Abdal & Ferreira, 2021). The resulting restrictive measures had profound economic consequences across industry, trade, and services—particularly in sectors where physical proximity between providers and clients is fundamental to the business model. Tourism and the MICE sector have been among the first to be hit by these severe consequences. The lockdown induced by the pandemic had immediate and severe consequences for the meetings and exhibition industry. Due to the social distancing measures, most exhibition organisers had to cancel or postpone business events they had already organised. During the first two waves of the coronavirus epidemic, exhibition events have been almost entirely suspended; a gradual resumption only began in 2022. Certain limitations of exhibition-related activities (e.g. capacity limits on visitors in enclosed spaces) were in force until the end of 2022. It was not until 2023 that a significant upward trend in the sector was observed.

The Global Barometer survey conducted by UFI measured how exhibition organisers in each country rate their activity. Based on responses from 459 industry players from 62 countries, UFI categorised the level of activities as either *"normal", "reduced"* or *"no activity"*. The survey, conducted in June 2020, revealed shocking results: while in January 2020, 85% of respondents rated their activity as normal, this figure plummeted to 5% by March. In April and May, 73% of exhibition organisers reported a total cessation of business operations (UFI, 2020). According to the survey conducted in January 2021, while 45% of the Barometer respondents had expected an increase in profits of more than 10% in 2019 compared to the previous year, in 2020 the average turnover of respondents was only 28% of that in the previous year. 52% of the exhibition organisers surveyed were making a loss, and a third had lost 50% of their profits (UFI, 2021). The Barometer survey is conducted every six months, and by June 2022, the results showed that turnover levels reached 73% of those in the pre-pandemic period. Industry players began to evaluate prospects optimistically, expecting to reach 2019's turnover levels by the first half of 2023[6]. This proved to be valid, as the June 2023 report announced that the expected revenues for 2023 were around 97% of the 2019 figures, with some industry players even expecting to exceed the 2019 results. The years 2022 and 2023 represented a *"bounce-back"* for the industry. This recovery was driven not only by the gradual lifting of trade and social distancing restrictions but also by the strategic emergence of digitalized services integrated into trade show events.

UFI's statistical data and trends witnessed in the exhibition industry align closely with the World Trade Organisation's report on global trade. The same *"bounce-back"* effect can be observed in the case of commercial services, travel, and tourism (WTO, 2022). While in the digital service sector, especially computer services, telecommunication and online learning and streaming, significant growth could be observed even during the pandemic period, and world exports have increased by 44% in 2023 compared to the previous year[7]. Digitalisation has emerged as a critical strategic priority, as adapting to a rapidly shifting external environment has become a primary challenge. Effective management changes and the internal improvement of the business models are crucial to maintaining market positions. Simultaneously, customer expectations have changed due to the widespread adoption of digital solutions that have now become standard within the exhibition market.

[6] UFI The Global Exhibition Barometer, https://www.ufi.org/archive-research/the-global-exhibition-barometer-july-2022/

[7] World Trade Organisation (WTO), https://stats.wto.org/

Research question and methodology

This research aims to investigate the digital transformation of the Hungarian MICE sector, specifically within the context of the COVID-19 pandemic. By employing a mixed-method approach—integrating both qualitative and quantitative techniques—the study provides a comprehensive analysis of the sector's adaptation, challenges, and future potential. The methodology encompasses a systematic literature review, secondary data analysis, and semi-structured interviews designed to elicit insights into the digitalization trends and future outlooks of key actors within the Hungarian conference and exhibition market.

Drawing upon the literature review and data analysis, the study addresses the following research questions:

- How has the pandemic influenced the digitalisation of the meetings sector?
- What are the development trends of the Hungarian MICE market?
- What are the preferences of Hungarian MICE stakeholders regarding online versus in-person participation?
- What changes should be made to the way companies participate at exhibitions and conferences in response to the shifting demands of exhibitors?

The research adopts a mixed-method approach to understanding the digitalisation trends within the MICE sector. Research methodology and research design follow the research onion model of Saunders (Saunders et al., 2016). This design facilitates the integration of numerical data and nuanced stakeholder perspectives. The primary objectives are to explore the role of the pandemic in accelerating digital transformation in the Hungarian MICE sector, examine stakeholder preferences for digital, hybrid, and in-person formats, and analyse the adoption, efficacy, and barriers associated with digital tools in Hungarian MICE activities relative to global benchmarks.

Data collection and analysis methods

To answer these questions comprehensively, the methodology employs mixed-data collection strategy. A systematic review of existing academic literature and industry datasets establishes the theoretical framework, encompassing global trends in MICE digitalisation, pandemic-induced innovations, and specific case studies from Hungary. Particular attention is paid to studies documenting the evolution and integration of digital tools, such as virtual exhibitions, augmented reality showrooms, and online matchmaking platforms.

Structured surveys form the basis of the quantitative data collection, targeting key stakeholders such as event organisers, exhibitors, and participants within the Hungarian MICE sector. The surveys focuses on the adoption rates of and experiences with digital tools, preferences regarding event formats (digital, hybrid, or in-person) and the factors influencing the choice of format, including costs, audience reach, and technological capabilities. Secondary data from industry reports, including the UFI Barometer Reports and governmental publications, supplement survey findings, offering comparative insights into Hungary’s digitalisation levels relative to global trends. Regarding the quantitative analysis, the survey data is analysed using descriptive statistics to identify trends and stakeholder demographics, while comparative analysis benchmarks Hungary’s digitalisation maturity against international standards. Qualitative data collection is used to gather stakeholder experience and gain a better understanding of the challenges they face. Qualitative methods include semi-structured interviews with organisers, exhibitors, and participants, who provide contextual data about their experiences, motivations, and barriers to

embracing digital formats. Qualitative and thematic analyses is employed to extract recurring themes and insights from interviews. Content analysis further enriches the interpretation of open-ended survey responses.

To ensure representation across a broad spectrum of stakeholders actively involved in the Hungarian exhibitor sector a purposive sampling approach was adopted (Saunders et al., 2016). The sample includes exhibitors from various event types (trade fairs, conferences, and exhibitions) and attendees with varying levels of engagement in digital or hybrid formats. Data collection is supported by key cooperating partners, including export promotion agencies, conference organisers, and various umbrella institutions in Hungary. Target sample size is set at a minimum of 20–30 exhibitors and 3–4 interviewees. The findings are expected to contribute to the broader academic discourse on the impact of digital transformation in post-pandemic tourism and business sectors. By employing this systematic methodology, the study aims to provide a well-rounded perspective on the digital evolution of Hungary's exhibition, fair and MICE sector, addressing existing gaps in industry practice and available data and reports from the sector in Hungary.

Discussion: impact of the pandemic on the digitalisation of the MICE sector

The development of digital tools at fairs and exhibitions

An important mission of modern-day exhibitions is to disseminate the latest trends and developments in the industry, to provide a platform for showcasing
innovations and the announcement of new releases (Chlodnicki et al., 2011). Although digital services related to exhibitions had begun to permeate the sector prior to 2020, the pandemic necessitated an immediate shift from face-to-face interaction to a much more rigorous application of online solutions (Vitali et al., 2022). As Vitali (2022) observes, in the early 2000s, the first phase was characterized by the spread of the Internet and online marketing tools, where exhibition organisers began utilizing online platforms to recruit both exhibitors and visitors. Exhibitors adopted digital advertising tools to reach their target audience and promote their physical presence at the exhibition event. The emergence of social media further enhanced the possibilities for reaching their audience, especially in pre- and post-event marketing, to maximise visitors acquisition (Vitali et al., 2022). More recently, the integration of Radio Frequency Identification (RFID) technology and social media algorithms has enabled a much more complex and comprehensive analysis of visitor behavior and motivations. Such solutions can be used for on-site visitor tracking, designing optimal booth layouts, effective traffic flow, or enhancing security protocols. For instance, RFID-embedded badges allow for the precise monitoring of attendee density, which is critical for safety measures such as emergency evacuations.[8] Virtual trade shows were created to complement or extend events, in addition to personal presence (Vitali et al., 2022).

By the end of the 2010s, digital supplementary services for exhibitions and fairs had become widely available. Based on exhibition websites, personal experience, and relevant literature, the most common and typical digital supplementary services are the following:

- Matchmaking and online partner search databases.
- Online meeting platforms.
- Online conferences, seminars, and learning tools.
- Virtual showrooms.
- Virtual booths.
- Games or interactive tools.

[8] See example: https://www.expotoolsusa.com/attendee-tracking/

- Live streaming applications.
- Augmented reality showcases.
- Virtual reality (VR) meeting rooms and VR games.

Despite the availability of these tools, personal selling remained the focal point of fairs and exhibitions, as described by several authors (Skoko et al., 2022; Zhang et al., 2023). Rather than replacing in-person promotion, these digital solutions appeared alongside it as a complementary, additional element of the service package (Li et al., 2022). At the time of the pandemic outbreak, many of the above-mentioned digital solutions were already widely available, while others were still in development or undergoing continuous evolution. The initial cost of incorporating new technological solutions is high, which makes them less accessible to a broad customer group. However, the lockdown caused by the pandemic in the exhibition market generated an immediate and enormous demand for digital solutions (Skoko et al., 2022). As a result, ongoing developments were accelerated, or developers allocated significant additional resources to introduce new features[9].

To evaluate the impact of the pandemic on digitalisation within the exhibition industry, this study refers to the June 2023 Barometer Report of UFI. (UFI, 2023), which provides a comprehensive overview of digital maturity and future trends. One of the most significant changes is that 64% of exhibition organisers have broadened their service package to include digital-type services such as visitor applications, advertising tools or other services. Furthermore, more than half of the respondents invested in the digitalisation of internal workflows and processes. These developments are mostly driven by the intense market competition, and the pursuit of the operational efficiency of the exhibition organiser. The strategic importance of this shift is further evidenced by the fact that one in four exhibition organisers has developed a digital transformation strategy. Additionally, 20% of global industry actors have either created a position in the management responsible for digital services or developed a "*digital product not directly related to an existing trade show or exhibition"* (UFI, 2023).

A review of several examples and case studies from recent academic literature suggests that the need for digitalisation and a highly competitive market, characterised by the changing expectations of visitors, has already existed globally. This presents a challenge for smaller countries with less-developed infrastructure compared to developed countries with more resources for future investments (Skoko et al., 2022).

Expected results of the research

Hungexpo, the largest exhibition venue provider in Hungary, and a member of UFI, does not currently offer any virtual or online solutions to accompany its events, as can be seen on its website. Consequently, the research questions and existing data and information were addressed by conducting a semi-structured interview with the state actor's representative responsible for conference tourism in Hungary. This is the first interview in a planned series, and we received the following insights from the Budapest Convention Bureau. The interview primarily explored the role of digitalisation in Hungary's MICE sector, the challenges encountered during its implementation, and the evolving trends in the industry. In the semi-structured interview, Ms Molnár-Győri Noémi, sales director, discussed the impact of digitalisation on Hungary's MICE sector, its gaps, and future opportunities. The key trends and challenges identified by the interviewee in Hungary are as follows: the pandemic accelerated the adoption of digital tools, such

[9] An example of this is the continuous expansion of streaming and online meeting features in applications like Microsoft TEAMS or ZOOM during the pandemic.

as hybrid events, matchmaking platforms, and virtual reality. Hybrid events initially surged in popularity but are now diminishing in larger conferences as in-person interactions regain importance. Despite these advancements, challenges such as limited budget allocation, inconsistent data collection, and stakeholder reluctance to share information are hindering the full realisation of digitalisation's potential. Regarding the competitive position of Hungary, Ms Molnár-Győri stated, that the country's venues, particularly Hungexpo, are highly competitive due to their advanced infrastructure. However, insufficient four-star hotel capacity limits the ability to host large-scale events. Budapest's unique blend of historical charm and modern infrastructure remains a key strength in attracting international events. Looking to the future, the sales director emphasised that the sector is gradually embracing sustainability, although client demand for eco-friendly practices remains inconsistent. Improved data collection systems, enhanced collaboration among stakeholders, and high-precision digital marketing are critical for future growth. Maintaining a balance between digital and in-person formats, alongside Budapest's unique appeal, is essential for Hungary to remain competitive in the global MICE industry as well as in the leisure tourism sector. Further, semi-structured interviews will be conducted with stakeholders such as the Budapest Congress Centre and HUNGEXPO, as well as agencies involved in Hungarian export development, including the Hungarian Agricultural Marketing Centre[10] and the Hungarian Export Promotion Agency[11], and their SME exhibitors. We expect these interviews to provide further insights and opinions from stakeholders about the current digital opportunities in the MICE sector – from both the host's and the participant's perspectives – as well as about its development opportunities and expectations.

Conclusions and further research

The MICE industry encountered unprecedented challenges during the COVID-19 pandemic, leading to the rapid adoption and evolution of digital tools and services. Despite the increased reliance on digital solutions during this period, the enduring value of in-person interactions remains evident. The physical presence of attendees at trade fairs and exhibitions remains essential, emphasising the need for a balanced integration of digital and traditional formats. While digitalisation has introduced new opportunities, such as enhanced efficiency and broader accessibility, it has also raised challenges, including cybersecurity threats and geopolitical risks. The sector now requires strategies that combine digital innovations with the experiential and interactive qualities of physical events. This approach not only meets changing consumer expectations but also ensures the industry's relevance and growth. The pandemic underscored the importance of adaptable business models and advanced technologies, such as virtual reality, virtual showrooms and streaming to optimise operations and reduce costs. These tools can enhance internal processes and provide cost-effective alternatives for showcasing products and facilitating meetings. In conclusion, the research will provide insight into the digitalisation trends within the Hungarian MICE sector, by building upon insights gained through a series of carefully planned semi-structured interviews and surveys. These interviews aim to gather perspectives from key stakeholders and industry players, thereby enriching the overall understanding of current practices, challenges, and future opportunities in the Hungarian MICE sector.

[10] https://en.amc.hu/
[11] www.hepa.hu

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The Impact of Chinese Investments in Hungary on the Sustainability of Global Value Chains: Challenges and Future Opportunities

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Abstract

This study examines the impact of Chinese foreign direct investment (FDI) in Hungary on the sustainability of global value chains (GVCs). Drawing on data analysis and literature review, the paper highlights how Chinese investment has facilitated Hungary's industrial modernization, technological upgrading, and green transition, particularly in the automotive, electronics, and high-tech sectors. The findings show that while Chinese FDI contributes to economic growth, technology transfer, and environmental sustainability, it also introduces significant challenges, including investment volatility, policy and regulatory pressures, and the risk of economic dependency. Hungary's participation in the Belt and Road Initiative (BRI) further strengthens its role as a strategic hub in Central and Eastern Europe, enhancing regional integration while simultaneously raising concerns about long-term reliance on foreign capital. The paper concludes with policy recommendations, emphasising the need for Hungary to balance foreign and domestic interests, promote green investment, and strengthen its capacity for innovation to ensure the sustainable integration of Chinese investment into global value chains.

Keywords: Chinese Investment, Hungarian Economy, Global Value Chain (GVC) Sustainability, Belt and Road Initiative (BRI), Foreign Direct Investment (FDI), Industrial Upgrading

JEL classification: F13

Introduction

As global economic integration deepens, global value chains (GVCs) are playing an increasingly important role in promoting international trade, technological innovation, and industrial development (Gereffi & Korzeniewicz, 1993). As the world's second-largest economy, China has become a key player in the global value chain. China's investment in Hungary has not only driven economic growth but also had a profound impact on regional economic integration and the sustainability of global value chains. Since the launch of the Belt and Road Initiative (BRI), Hungary, being a key country along the BRI route, has become a prime destination for Chinese outward investment (Gáspár, Sass, & Koppány, 2023).

This article aims to explore how Chinese investment has influenced Hungary's economic development, particularly with regard to the sustainability of global value chains. It will analyse how Chinese investment in Hungary has facilitated industrial modernization, enhanced resource efficiency and environmental standards, while also addressing the regulatory and environmental challenges encountered in this process (Wong & Downes, 2024). Finally, the article will provide policy recommendations to assist Hungary in maximizing investment returns while addressing potential risks and challenges (Vélgyi & Lukács, 2021).

The Relationship Between Global Value Chain Sustainability and Chinese Investment

The Concept and Development of Global Value Chains

GVCs refer to the complex networks formed between multinational corporations and countries through production, distribution, and sales activities across the globe. The formation of GVCs has accelerated the globalization process, particularly as developing countries have integrated into global value chains. This has given them access to technology, capital, and management expertise, thus driving the industrialization of their economies (Gereffi & Korzeniewicz, 1993). The sustainability of GVCs involves maximizing economic benefits while also considering social and environmental impacts. In recent years, the concept of sustainable development has gained prominence, and governments and businesses worldwide have focused on achieving resource efficiency and minimizing environmental impacts within global value chains (Fitzgerald, 2020).

China's Role in Global Value Chains

As a global manufacturing hub, China has become an indispensable part of the global value chain. Not only is China a production base for global manufacturing, but it is also an important importer of raw materials and consumer goods (Liu, 2019). China's "going global" strategy, particularly in the context of the Belt and Road Initiative, has fuelled the rapid growth of Chinese foreign direct investment (FDI) overseas. These investments have not only helped Chinese enterprises expand their markets while promoting the economic development of recipient countries and deepening the integration of global value chains (Gáspár, Sass & Koppány, 2023). Chinese investment in Hungary, particularly in high-tech industries such as automotive, electronics, and machinery manufacturing, has facilitated the transformation and modernization of local industries, providing new impetus for Hungary's economic growth.

Hungary's Strategic Position and Economic Dependency

As an important economy in Central and Eastern Europe, Hungary's geographic location has established it as a bridge between the Eastern and Western markets. Since joining the European Union in the early 2000s, Hungary has fostered industrial modernization and economic development through FDI (Varga & Keresztúry, 2020). The country's economic structure has gradually shifted towards high-value-added manufacturing and service industries, particularly in the automotive, electronics, and information technology sectors (Varga, 2018).

However, Hungary's economy faces several challenges, including rising labour costs, fluctuating market demand, and external economic pressures (Csanadi & Hunya, 2019). Consequently, the Hungarian economy is heavily reliant on foreign investment, particularly from China, which has alleviated some of these issues and driven industrial upgrading and sustainable development (Liu, 2021).

Chinese Investment in Hungary and the Sustainability of Global Value Chains

Chinese investment in Hungary is reflected not only in capital inflows but also, and more importantly, in technology transfer and shared management expertise. These factors have modernized Hungary's industrial chain. In the automotive manufacturing sector, for example, Chinese investment has not only provided financial support but also facilitated technological innovation and improvements in production efficiency within Hungary's high-end manufacturing sectors (Zhou & Ma, 2021). Furthermore, Chinese enterprises have also contributed to

environmental sustainability by introducing green technologies and investments. This has helped Hungarian companies improve resource efficiency and reduce environmental pollution during production, thus promoting the sustainability of global value chains (Fitzgerald, 2020). However, the expansion of investment poses regulatory challenges for Hungary. For instance, balancing foreign investment inflows with the protection of domestic enterprises, or managing the environmental impact of foreign investments, are crucial issues that the Hungarian government needs to address (Huang & Li, 2019).

The Impact of the Belt and Road Initiative on Hungary

Overview of the Belt and Road Initiative

The BRI is an initiative proposed by China aimed at promoting global infrastructure development and economic cooperation. Since its launch in 2013, it has become one of the most widespread international cooperation frameworks in the world. Spanning across regions such as Asia, Europe, and Africa, the initiative aims to facilitate regional economic integration and promote balanced global economic growth by constructing trade and investment cooperation platforms (Gereffi & Korzeniewicz, 1993).

As an important BRI partner, Hungary has actively participated in infrastructure development and economic cooperation projects under the initiative. These collaborations have not only promoted Hungary's economic development but also provided opportunities for Chinese enterprises to access the European market (Gáspár, Sass & Koppány, 2023).

Hungary's Role in the Belt and Road Initiative

Leveraging its geographical advantage and European Union membership, Hungary plays a pivotal and bridging role in the Belt and Road Initiative. Hungary has participated in several BRI projects, particularly in the fields of infrastructure, logistics, and energy (Liu, 2021). These projects have not only boosted Hungary's economic development but also facilitated regional economic integration.

Under the framework of the Belt and Road Initiative, China's investment in Hungary has significantly increased, especially in transportation, energy, and high-tech industries. Through the BRI projects, Hungary has received substantial infrastructure investment, which has not only improved its transportation network but also enhanced its position in the global value chain (Csanadi & Hunya, 2019).

Direct and Indirect Impacts on Hungary's Economy

The Belt and Road Initiative has driven the diversification of Hungary's economy. Directly, Hungary has benefited from China's financial and technical support, which has improved its infrastructure and advanced industrial modernization. Indirectly, the BRI has strengthened Hungary's economic cooperation with other Central and Eastern European countries, fostering regional economic integration. Hungary's manufacturing and service sectors have gained access to new markets, which has injected new vitality into the local economy (Varga & Keresztúry, 2020).

However, these investments have also introduced new challenges. Key issues that Hungary needs to address include how to effectively manage external capital inflows and balance the competitive relationship between foreign and domestic enterprises (Zhou & Ma, 2021).

Foreign Direct Investment and Economic Development in Hungary

The Concept and Types of Foreign Direct Investment (FDI)

FDI refers to long-term investments made by foreign enterprises through establishing or acquiring businesses in another country, purchasing equity stakes, or forming joint ventures. The main types of FDI include Greenfield Investment, Mergers and Acquisitions (M&A), and Joint Ventures. The development and influence of these investment forms vary across different countries and regions, as does their impact on the local economy.

FDI brings capital, technology, management expertise, and market entry opportunities. For Hungary, FDI is particularly significant as it has helped elevate the country's position within global value chains. With China becoming a major source of investment in Hungary, particularly in high-tech sectors, the country has undergone a significant economic transformation.

Trends in Chinese Foreign Direct Investment

According to data from the OECD, Chinese foreign direct investment in Hungary has been on the rise.

	Minimum	Maximum	Mean	Std. Deviation
Total Overseas Direct Investment Stock	88264242.00	278514971.00	183673608.3750	68577399.57988
Asia	60096561.00	177201520.00	119648766.5000	41941062.05716
Hong Kong, China	50991983.00	154965764.00	103659005.7500	37339595.06991
Indonesia	679350.00	2008048.00	1262076.5000	475445.31255
Japan	254704.00	488287.00	357934.3750	75762.62912
Macao, China	393074.00	1123624.00	832744.7500	256850.38397
Singapore	2063995.00	6720228.00	4505363.8750	1555833.47648
Republic of Korea	277157.00	705473.00	546625.7500	164674.17661
Thailand	307947.00	991721.00	603585.6250	246030.73409
Vietnam	286565.00	1085211.00	603675.1250	268048.20718
Africa	3235007.00	4610353.00	4103720.0000	499360.30566
Algeria	164352.00	255248.00	207087.6250	38569.38282
Sudan	110434.00	180936.00	132829.5000	28717.27530
Guinea	38272.00	95933.00	60410.3750	21076.68752
Madagascar	27291.00	80335.00	44426.3750	21342.11288
Nigeria	219400.00	286153.00	247672.5000	21590.32428
South Africa	472297.00	747277.00	600503.0000	86144.43401
Europe	6939987.00	13479438.00	10444281.1250	2207437.26330
United Kingdom	1280465.00	2031817.00	1763071.7500	235161.74555
Germany	578550.00	1669749.00	1135523.5000	425027.15634
France	486095.00	844488.00	590816.1250	118350.06907
Russia	869463.00	1420822.00	1241157.0000	190779.04223
Latin America	10611113.00	69374017.00	37410553.1250	21834148.63096
Cayman Islands	4423672.00	45702699.00	21030659.3750	13639721.40633
Mexico	52476.00	130216.00	90995.7500	31982.16147

Virgin Is. €	4932041.00	44747734.00	14841463.7500	12721512.76510
North America	4795149.00	10022580.00	8241564.6250	2174095.95100
Canada	778908.00	1409147.00	1160758.1250	234191.52920
United States	3801097.00	8004771.00	6466234.5000	1684817.11104
Oceania	2586425.00	4411078.00	3824723.1250	625623.57597
Australia	2388226.00	3837868.00	3338735.8750	496093.64615
New Zealand	96241.00	312871.00	222661.0000	76832.55721

Table 1: *OECD Overseas Direct Investment Stock*
Source: *OECD*

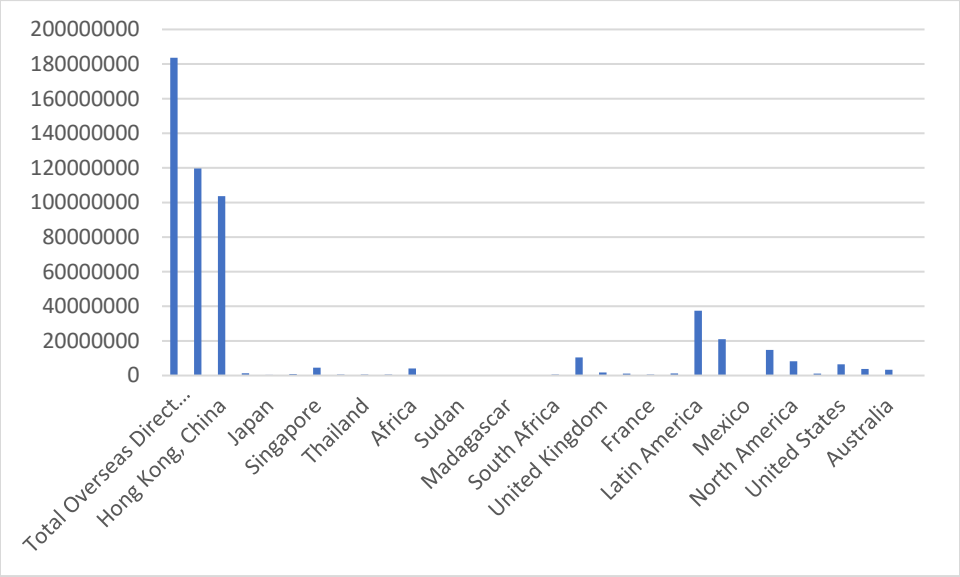

Figure 1: *OECD Overseas Direct Investment Stock*
Source: *OECD*

The following data, extracted from the analysis, help further understand the impact of Chinese investment on Hungary's economy:

- Investment Fluctuations: The data indicates that Chinese FDI in Hungary fluctuates significantly. The investment amount has increased from approximately 883 million RMB (Chinese yuan) to 2.785 billion RMB, highlighting considerable volatility and large variations between years. The average investment amount was 1.837 billion RMB, with a standard deviation of 686 million RMB.
- Investment Sources: The data shows that investments from Asia, especially Hong Kong and China, are prominent. Hong Kong's total investment stands at around 1.037 billion RMB, exhibiting significant volatility and indicating active investment activity.
- Europe and Africa Discrepancies: Compared to Asia, investments from Europe have been relatively stable. Hungary, as a major market in Central and Eastern Europe, receives the majority of its FDI from China and Germany, while investments from Africa are comparatively scarce.

Hungary's Demand for and Dependence on Foreign Direct Investment

As a small, open economy, FDI plays an essential role in driving Hungary's economic growth. According to Hungarian government statistics, FDI's share in Hungary's GDP has increased annually, especially in high-value-added sectors such as automotive manufacturing, electronics, and machinery production.

- Automotive Manufacturing: The country's automotive manufacturing industry has become an integral part of global value chains. Following the entry of Chinese investors, Hungary has become a production base for multiple international automotive manufacturers. Chinese investment has helped Hungary enhance its position in the global automotive supply chain.
- Electronics and High-Tech Industries: Beyond the automotive sector, Hungary's electronics industry has also benefited from Chinese FDI. Investments by Chinese companies in Hungary have improved local production efficiency and fostered technological innovation. Through joint ventures and technology transfer, Hungary has successfully integrated high-tech industries into its economic structure.
- Dependence Issues: However, Hungary's increasing reliance on foreign investment exposes it to risks from external economic fluctuations. In the context of rising global economic uncertainty, Hungary's dependence on foreign capital and technology could lead to over-reliance, thereby increasing the risk of external shocks.

Contributions of Chinese Investment to Hungary's Economic Growth and Industrial Upgrading

Chinese foreign direct investment in Hungary is not only reflected in financial inflows but also in the transfer of technology and management expertise. These investments have enabled Hungary to achieve industrial upgrading and economic growth in several areas:

- Industrial Upgrading: Chinese investments have facilitated Hungary's transition from low-value-added labour-intensive industries to high-value-added, high-tech sectors. For example, Hungary's production capacity in electronics and automotive components has significantly increased, with some Chinese companies establishing Hungary as a European production base.
- Green Investments: In recent years, Chinese enterprises have invested in green energy projects in Hungary, contributing to the country's transition to a low-carbon economy. These investments have helped Hungary reduce its carbon emissions and enhanced its competitiveness in the global green industry supply chain.
- Economic Growth: According to Hungary's statistical office, Chinese investment has contributed to an increase in the country's GDP. Chinese investment has boosted Hungary's industrial output and raised export volumes, particularly in the automotive and electronics sectors.

Data Analysis Results

From the data analysis, we can draw the following conclusions:

- Investment Volatility: Chinese investment in Hungary fluctuates significantly from year to year, reflecting the flexibility of Chinese investments and the uncertainty of the market. The Hungarian government should strengthen the management of foreign capital flows to ensure more stable external funding in global value chains.
- Concentration of Investment Fields: Chinese investment in Hungary is primarily concentrated

in the automotive manufacturing and the high-tech industries. These two sectors have driven Hungary's industrial transformation and increased its competitiveness in global value chains.
- Opportunities in Green Development: China's green investments offer Hungary opportunities for sustainable development. By introducing environmental technologies and energy-saving projects, Hungary can further enhance the greening of its industries, thereby aligning with the global value chain's sustainability goals.

Conclusion

China's foreign direct investment has had a profound impact on Hungary's economy. By injecting capital, transferring technology, and sharing management expertise, Hungary has not only achieved industrial upgrading but also spurred economic growth. Despite issues such as investment volatility and dependence on foreign capital, Hungary can maximize the benefits of FDI and effectively address associated risks through policy guidance and strategic planning.

Challenges and Future Opportunities

Major Challenges Faced by Hungary

Although China's FDI has positively impacted Hungary's economy, the country still faces a series of challenges in this process. In the context of globalization and regional economic integration, achieving a balance between economic growth and sustainable development has become a pressing issue for Hungary.

Dependence on Foreign Investment and Risk

Hungary's economy is heavily reliant on foreign direct investment, especially from China. While foreign investment brings capital and technology, over-reliance on foreign capital could expose Hungary to considerable risks during periods of global economic instability. Specifically, financial market fluctuations, changes in global demand, and factors such as the US-China trade war could influence the scale and direction of Chinese investment in Hungary (Gáspár, Sass & Koppány, 2023). This dependency makes Hungary's economy vulnerable to external shocks and impacts its long-term sustainable development.

Policy and Regulatory Challenges

The Hungarian government needs to develop effective policies to ensure a stable flow of foreign investment while also balancing the competitive relationship between domestic and foreign enterprises. Currently, Hungary is grappling with the challenge of overseeing and enhancing the configuration of foreign investment. Particularly in areas such as industrial upgrading, green investment, and high-tech sectors, in particular the government must focus on guiding foreign investment into sectors that will benefit the country in the long term (Varga & Keresztúry, 2020).

Environmental and Social Challenges

As the scale of investment increases, Hungary is facing an array of growing environmental and social challenges. Although Chinese investment has introduced environmental technologies and green energy projects, Hungary needs to address issues such as environmental pollution, resource waste, and social inequality, all the while maintaining industrial growth (Huang & Li, 2019). In

traditional industries, which tend to be high polluters and energy consumers, achieving a green transition remains a key focus for both the Hungarian government and enterprises.

Opportunities from Chinese Investment in Sustainable Development

Despite the challenges it faces, Hungary has significant opportunities arising from Chinese investment in sustainable development. Not only has Chinese investment promoted Hungary's industrial transformation but it has also provided new momentum for its economic growth.

Green Investment and Sustainable Development

As global attention on sustainable development and environmental protection increases, green investment has become a key component of China's investment in Hungary. Investments by Chinese companies in green energy, environmental technologies, and low-carbon industries are helping Hungary move towards sustainable development. For instance, Chinese enterprises have established wind and solar energy projects in Hungary. These projects not only reduce Hungary's carbon emissions but also enhance its technological capabilities and market competitiveness in the renewable energy sector (Fitzgerald, 2020).

Technology Transfer and Industrial Upgrading

Chinese investment in Hungary, particularly in high-tech industries, has modernized Hungary's industrial sectors. By cooperating with Chinese enterprises, Hungary has gained not only financial support but also technology transfer and knowledge sharing, enhancing the technological content and added value of its industries. In the automotive manufacturing and electronics industries, for example, Chinese companies have helped Hungary improve production efficiency and product quality, thereby boosting Hungary's competitiveness in the global value chain (Liu, 2021).

Market Diversification and Regional Cooperation

China's Belt and Road Initiative (BRI) has provided Hungary with more market opportunities and avenues for regional cooperation. Hungary can enhance its economic diversification by strengthening its cooperation with China and other countries along the BRI route. Through multinational collaboration, Hungary can open new markets and also participate in more international projects, thereby improving its position in the global economy (Zhou, 2020).

Challenges and Opportunities from the Trend of Global Economic Integration

As global economic integration progresses, Hungary's economy is facing increasingly complex challenges and opportunities. Globalization has brought market opportunities but has also intensified international competition. Hungary needs to find an adaptive role within global value chains, particularly in the areas of technology, innovation, and industrial upgrading.

Competition Between Multinational Corporations and Domestic Enterprises

Foreign enterprises, especially Chinese companies, play an important role in Hungary's economy. However, the continuous influx of foreign enterprises is putting growing competitive pressure on Hungarian domestic companies. Balancing the interests of foreign and domestic enterprises, especially in the areas of technological innovation, industrial transformation, and environmental protection, is a significant challenge for the Hungarian government.

New Opportunities in Global Value Chains

The sustainability of global value chains hinges on participating countries achieving mutual development, particularly in areas such as green development and technological innovation. Chinese investment could strengthen Hungary's position in these chains, especially in sectors like environmental protection, information technology, and smart manufacturing. By leveraging Chinese technology and capital, Hungary could further connect with international markets and drive economic transformation (Huang, 2021).

Policy Recommendations and Strategic Planning

To address the challenges outlined above and seize the opportunities, Hungary could implement the following policies and strategic plans:

- Enhancing Foreign Investment Management: The Hungarian government should implement reasonable policies to ensure the stability and sustainability of foreign investment inflows. Additionally, it should strengthen the supervision of foreign enterprises to prevent excessive resource depletion and ensure that domestic companies have opportunities to develop in the competitive landscape.
- Promoting Green Transition: Hungary should continue to support Chinese investment in green energy and environmental technologies to drive a nationwide green and low-carbon transition. By investing in green technologies, Hungary can reduce environmental pollution and enhance its position in the global green industry chain.
- Strengthening Regional Cooperation: Hungary should capitalize on the opportunities provided by the Belt and Road Initiative to further strengthen its cooperation with China and other Central and Eastern European countries. Through regional cooperation, Hungary can access new markets and development opportunities, thereby boosting its international competitiveness.
- Supporting Innovation and Technology Transfer: Hungary should actively attract foreign investment in high-tech fields, particularly in smart manufacturing, artificial intelligence, and information technology. By encouraging technology transfer and innovation collaboration, Hungary can enhance the competitiveness and added value of its industries, achieving high-quality development.

Conclusion

Overall Impact of Chinese Investment on Hungary's Economy

This paper has examined China's foreign direct investment (FDI) in Hungary, investigating its effects on the Hungarian economy and the sustainability of global value chains. Based on data analysis and a literature review, the following conclusions can be drawn:

1. Economic Growth and Industrial Upgrading: China's investments have brought significant economic growth and industrial upgrading to Hungary. Particularly in sectors such as automotive manufacturing, electronics and information technology, and high-end manufacturing, China's investment has helped elevate Hungary's position within global value chains. These investments have not only injected capital but have also driven industrial modernization through technology transfer and the sharing of management expertise (Gáspár, Sass & Koppány, 2023).
2. Green Transition and Sustainable Development: Green investment has become a critical

component of Chinese investment in Hungary. Through investments in environmental technology, green energy, and low-carbon industries, Chinese companies have helped Hungary transition towards a sustainable development model. This has not only helped Hungary reduce its carbon emissions but has also enhanced its competitiveness within the global green industry supply chain (Fitzgerald, 2020).

3. Investment Volatility and Risk: While Chinese investment has supported Hungary's economic growth, there has been considerable volatility in these investments. The fluctuation in investment amounts indicates the instability of Chinese investment, exposing Hungary to substantial risk in the event of external economic shocks. Therefore, Hungary needs to focus more on managing foreign capital flows and reducing its dependence on foreign investment (Csanadi & Hunya, 2019).
4. Policy Challenges and Management: The Hungarian government needs to implement more effective policies to ensure the sustainability of foreign investment inflows and strengthen the competitiveness of domestic enterprises. During this process, it is crucial for the government to strike a balance between the interests of foreign and domestic enterprises, particularly with regard to technology transfer, industrial upgrading, and environmental protection. This will help ensure that foreign investments do not have a negative impact on the domestic economic structure (Huang & Li, 2019).

Long-Term Impact of the Belt and Road Initiative on Hungary

The BRI has brought Hungary unprecedented development opportunities. Not only has Hungary become a key hub for Chinese investment in Central and Eastern Europe but it has also enhanced its economic cooperation with other countries through the initiative. By participating in BRI projects, Hungary has established close ties with China in various areas, including infrastructure development, energy cooperation, and trade.

1. Infrastructure Development: Through the financial support provided by the Belt and Road Initiative, China has helped Hungary improve its infrastructure in areas such as transportation and energy. This has modernized Hungary's infrastructure, providing significant support for its economic growth.
2. Regional Economic Integration: The BRI has further strengthened Hungary's economic cooperation not only with China but also with other countries in Central and Eastern Europe. This collaboration has boosted Hungary's economic growth and promoted economic integration across the entire Central and Eastern European region (Liu & Wang, 2021).
3. Long-Term Sustainability: While the Belt and Road Initiative has provided significant development opportunities for Hungary, it has also posed challenges to its policies and governance. To ensure long-term sustainability, Hungary must guarantee that the investments associated with the BRI align with sustainable development goals and avoid over-reliance on foreign capital, which could lead to economic instability (Zhou & Ma, 2021).

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Transforming Tyre Sales: A Subscription-Based Approach for Enhanced Customer Experience and Sustainability

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Abstract

The tyre industry is facing the challenge of transforming its traditionally low-involvement product into one that actively engages consumers. This paper examines the potential of a subscription-based tyre sales model, which would replace infrequent, high-cost purchases with predictable monthly payments. Drawing on industry insights and technological advances in data analytics, predictive maintenance, and customer experience management, the study demonstrates how this model can reshape consumer perceptions. The findings show that subscription services foster stronger customer loyalty, reduce downtime through proactive maintenance, and extend tyre lifespan by enabling timely interventions. A case study of Pirelli's implementation of the model demonstrates its clear benefits, including enhanced brand loyalty, steady recurring revenue, and reduced environmental impact through more efficient use of resources. The results indicate that the subscription model meets evolving consumer expectations for convenience and sustainability while providing manufacturers with a scalable, service-oriented business strategy that aligns with broader mobility trends.

Keywords: tyre as a service, subscription-based model, marketing, tyre industry, sustainability, data analytics, end-user interface, CRM (Customer Relationship Management), smart logistics, carbon footprint

JEL classification: M3

Introduction

This study explores the potential of a subscription-based model to transform the tyre industry, providing fresh insights into a sector traditionally seen as mundane. The tyre industry has long struggled to engage consumers, as conventional purchasing methods are often inconvenient, time-consuming, and financially burdensome. This paper proposes a new approach in the form of a subscription-based tyre model, which aims to shift consumer perceptions and offer a more seamless, predictable, and customer-centric experience. By leveraging technological advancements and predictive maintenance, the proposed model seeks to transform how tyres are purchased, managed, and maintained.

The study is grounded in a combination of practical industry expertise and academic insight. One of the authors has over a decade of experience in the tyre industry, having managed operations in more than 70 countries and worked with industry giants like Michelin, Goodyear, and Pirelli. The other author is a marketing professor who has closely studied tyre brands as case studies in innovation, branding, and customer engagement. This combination of practical and academic

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perspectives provides a comprehensive understanding of the challenges and opportunities within the tyre industry.

The paper is structured to first examine the current landscape of the tyre industry. Section 2, Pioneering concepts in tyre technology, introduces emerging technological innovations that are reshaping tyre design. Section 3 presents the idea of "Tyres as a Service", exploring how the subscription model can transform traditional tyre ownership into an ongoing service agreement. Section 4, Why the current model is broken, examines the challenges consumers face in traditional tyre purchasing, such as high upfront costs and a lack of convenience.

In Section 5, The future of tyre innovation, the study discusses how ongoing innovation in tyre technology and customer service could pave the way for more sustainable and effective business models. Section 6, Current commercial challenges in tyre purchasing, highlights existing problems within the industry, such as pricing structures, market fragmentation, and the lack of transparency in the purchasing process.

Section 7, The future of tyre management: a subscription model, provides a detailed framework for how a subscription-based system could address these issues and improve both consumer experience and business efficiency. Section 8 covers technological integration and supply chain optimization, explaining how digital tools, smart logistics, and predictive maintenance can streamline operations and enhance customer satisfaction.

Section 9 of the paper includes a Case study on implementing the subscription model in the Middle East, focusing on how market-specific challenges such as parallel imports and inefficient supply chains can be overcome using the subscription approach. Section 10, Benefits for customers and dealerships, discusses the advantages this model offers to both consumers and businesses, emphasizing predictability, convenience, and cost-efficiency.

Finally, the paper discusses the Future implications and opportunities for the tyre industry, considering how emerging trends such as electric vehicles and autonomous driving could further shape the industry. The conclusion summarizes the study's findings, reaffirming the transformative potential of the subscription model in creating a more sustainable, efficient, and customer-focused tyre industry.

Pioneering Concepts in Tyre Technology

Peter Drucker, often referred to as the father of modern management, argued that the essence of any business lies in just two core activities: marketing and innovation (Drucker, 1973). This principle is vividly demonstrated in the tyre industry, where leading manufacturers are redefining their products and services to stay ahead of the competition in an ever-changing market. The tyre, traditionally viewed as a functional necessity, is being transformed into a high-tech product that embodies both marketing ingenuity and technological advancement.

Innovation in the tyre industry is not just about materials and durability; it is also about reimagining the role of tyres in mobility and sustainability. Henry Ford is famously quoted as saying that if he had asked people what they wanted, they would have asked for faster horses (Ford & Crowhter, 1922). Similarly, the tyre industry is surpassing consumer expectations by offering solutions that address contemporary challenges such as safety, performance, and environmental impact. Leading manufacturers like Goodyear, Hankook, and Michelin are pushing the boundaries of what tyres can achieve. Goodyear’s airless tyre, for instance, replaces air with internal strings that support the vehicle’s weight, thus eliminating the risk of punctures (Goodyear, 2023). Michelin has unveiled a groundbreaking 3D-printed tyre concept that adapts to the terrain and communicates with the vehicle to optimize performance (Michelin, 2023). These innovations demonstrate a shift

from viewing tyres as mere products to envisioning them as services, paving the way for subscription-based models that integrate seamlessly into the customer experience.

As Albert Einstein explained, intelligence is best reflected in a person's ability to change (Pais, 1982). The tyre industry exemplifies this adaptability, using innovation to meet current needs and foster long-term customer loyalty and sustainability.

Illustration 1: *Tyre Concepts*
Sources*:* *https://www.michelin.com/en/group/activities/tires/vision-concept*
https://www.hankooktire-mediacenter.com/hu/sajtokozlemeny/news/hankook-tire-presents-new-futuristic-concept-tyres-at-the-essen-motor-show-2018/?flt=1&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Baction%5D=detail&cHash=303ef4574f9b4192cae7bbe5893dd5e6
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The Idea of "Tyres as a Service"

Traditionally, buying tyres has been about ownership – a one-off transaction focused on price, durability, and performance. However, as the business landscape evolves, this model might soon become obsolete. Today's consumers are increasingly embracing the "subscription economy", a concept popularized by Tien Tzuo, who pointed out that the market is moving from products toward services (Tzuo, 2018). Imagine a subscription-based system where tyres are no longer something you purchase outright but instead subscribe to as a service. This shift aligns with the broader trend of prioritizing access over ownership, as seen in industries such as entertainment (e.g. Netflix and Spotify) and transportation (e.g. Uber and car leasing programs).

The tyre-as-a-service concept, inspired by the commercial tyre segment, has already been proven effective in sectors such as trucking and heavy machinery. In these sectors, companies

charge customers based on metrics such as cost per kilometer or cost per hour, offering flexibility and minimizing upfront investment. Henry Chesbrough's concept of open innovation further reinforces this trend by emphasizing that a company's current business model does not determine its future (Chesbrough, 2006). By rethinking traditional business models, tyre manufacturers can unlock new revenue streams and enhance customer satisfaction. The leap to passenger vehicles is not as far-fetched as it may seem. By adopting a subscription model, manufacturers could simplify the consumer experience, removing the stress of having to navigate various tread types, sizes, and performance ratings. As Steve Jobs, co-founder of Apple, famously noted, achieving simplicity can be more difficult than dealing with complexity, as it requires clear and focused thinking (Isaacson, 2011). With a subscription service, drivers could rely on seamless solutions that ensure they always have optimal tyres tailored to their needs and replaced automatically when necessary.

Moreover, this model offers significant marketing opportunities. Philip Kotler, often referred to as the father of modern marketing, stressed that marketing should be about creating real value for customers, rather than merely finding ways to sell what has been produced (Kotler, 2003). A tyre-as-a-service model does just that: it shifts the focus from selling a product to providing a value-rich experience, ensuring convenience, safety, and sustainability. By embedding customer-centricity at its core, this approach aligns with the growing marketing emphasis on long-term customer relationships over short-term sales. Additionally, the subscription model supports sustainability objectives by enabling manufacturers to assume greater responsibility for tyre disposal and recycling, thereby aligning with increasing consumer expectations for environmentally responsible business practices. Paul Polman, former CEO (Chief Executive Officer) of Unilever, warned that companies that do not help to solve global challenges will eventually become part of the problem themselves (Polman, 2020). By integrating sustainability into their business model, tyre manufacturers can appeal to environmentally conscious consumers while reducing their environmental footprint.

Illustration 2: *Subscription-based model*
Source: *authors' own presentation using Google images*

Why the Current Model is Broken

Tyre purchasing is rarely associated with positive consumer anticipation; it is often perceived as a necessary but unpleasant task, something like visiting the dentist — essential yet generally not welcomed. This analogy highlights a key problem in the tyre industry: customer engagement. The current tyre purchasing process is characterized by being unexpected, time-consuming, and requiring a one-time, often substantial, financial investment. It is also widely regarded as inconvenient, adding further stress to an already mundane task. Seth Godin, an American author, entrepreneur, and marketing expert, emphasized that people buy relationships, narratives, and a sense of magic, not just goods and services (Godin, 2009). Yet for many consumers, buying tyres lacks all three. The triggers for purchasing tyres are typically reactive, stemming from accidents, punctures, or inconvenient reminders from mechanics. This reactive model not only fails to prioritize customer experience but also reinforces the perception of tyres as a burdensome necessity.

In its current state, the tyre industry overlooks the value of proactive, customer-centric solutions. In its current form, the tyre industry may underutilize opportunities for proactive, customer-centric solutions. Jeff Bezos, the founder of Amazon, described customers as invited guests and the company as their host (Stone, 2007). If manufacturers adopted this mindset, they could transform a stressful transaction into a seamless and even enjoyable experience. Transitioning to a service model represents an opportunity to reimagine the customer journey, shifting the narrative from ownership to access and convenience.

The idea of transforming a traditionally routine consumption experience into a positive one is not new. Starbucks transformed coffee from a utilitarian commodity into an aspirational lifestyle product. Howard Schultz, who developed Starbucks into a global brand, emphasized Starbucks is less about selling coffee and more about serving people, with coffee as the medium through which that service is delivered (Schultz, 1997). Similarly, tyre manufacturers have the potential to move beyond their product's utilitarian image by focusing on customer experience, personalization, and convenience.

A tyre subscription model could eliminate the stress of ownership by replacing it with predictability and ease. Imagine a world where customers no longer have to worry about tread wear, punctures, or replacements. Instead, a subscription would ensure that their tyres are always in optimal condition. This approach addresses several pain points of the current purchasing experience, offering a hassle-free, cost-effective, and time-efficient alternative. By proactively addressing customer needs, manufacturers can capitalize on new opportunities to build loyalty and long-term relationships.

Adopting a service model also aligns with the growing emphasis on customer experience as a competitive differentiator. Tony Hsieh, the CEO of Zappos, emphasized that customer service ought to be the responsibility of the entire company, not just one department (Hsieh, 2010). A seamless, subscription-based tyre service could embody this philosophy, ensuring that every interaction adds value and fosters trust. Prioritizing customer convenience and satisfaction enables manufacturers to transform tyres from an inconvenient necessity into a stress-free solution, fundamentally reshaping how consumers view and interact with this essential product.

Illustration 3: *Current tyre purchase experience*
Sources: *authors' own presentation using Google images*

The Future of Tyre Innovation

The shift towards tyres as a service is not happening in isolation; it aligns seamlessly with the increasing digitalization of the automotive industry. Klaus Schwab, founder of the World Economic Forum, has stated that we are entering a period of profound transformation in the way we live, work, and connect with each other (Schwab, 2016). This revolution, known as the Fourth Industrial Revolution, is characterized by the convergence of physical, digital, and biological technologies. Smart tyres equipped with sensors and communication capabilities exemplify this integration, offering benefits that extend far beyond traditional tyre performance. These smart tyres can monitor wear, adapt to road conditions, and notify drivers when replacements are necessary, eliminating the need for visits to a service center. Leveraging Internet of Things (IoT) technology ensures continuous connectivity among vehicle, driver, and service provider. Kevin Kelly, co-founder of Wired magazine, observed that the future of many startups can be summed up simply: take any idea and add artificial intelligence to it (Kelly, 2016). Smart tyres are a perfect example of this approach, incorporating AI and data analytics to enhance safety, efficiency, and customer convenience.

Moreover, when combined with 3D printing technology, smart tyres have an even greater transformative potential. 3D-printed tyres can be customized to adapt to various terrains and conditions, reducing waste and lowering production costs. Don Tapscott, a leading authority on the impact of technology on business and society, views the digital economy as being driven by connectivity, customization, and sustainability (Tapscott, 2014). These advancements improve performance and support environmental goals by extending the lifecycle of materials and minimizing resource consumption.

The integration of digital and manufacturing innovations also enables manufacturers to adopt more sustainable business practices. Paul Hawken, an environmentalist, entrepreneur, and author, argues

in his sustainability framework that the economy is fundamentally dependent on the environment, rather than vice versa (Hawken, 1993). By embracing technologies that reduce waste and environmental impact, the tyre industry is taking significant steps towards creating a more circular economy.

Finally, these innovations reflect the broader trend of customer empowerment in the digital age. As Bill Gates, co-founder of Microsoft, noted, technological progress relies on integrating it so seamlessly into daily life that it goes unnoticed (Gates, 1999). Smart, connected, and customizable tyres exemplify this principle, making cutting-edge technology intuitive and accessible to drivers, redefining the way they interact with one of their vehicle's most essential components. The tyre-as-a-service model introduces a groundbreaking shift in how consumers approach tyre ownership and maintenance. As Illustration 4 shows, this model is centred on three core benefits: predictable service, anticipated costs, and immediate convenience. Together, these elements address the long-standing pain points of the traditional tyre purchasing process, including its unpredictability, time-consuming nature, high upfront cost, and inconvenience.

- Expected Service: Consumers receive regular reports providing real-time updates on tyre conditions, including wear and performance metrics. This level of transparency eliminates the uncertainty often associated with traditional tyre management. For instance, platforms like Mypirelli.ae can deliver comprehensive diagnostic reports, ensuring that customers are always informed about their tyres' condition.
- Predicted Costs: The subscription model replaces the financial burden of one-off, high-cost investments with predictable monthly instalments. This approach aligns with the growing consumer preference for affordability and flexibility, enabling better financial planning and reducing the stress of unforeseen expenses.
- Instant & Convenient Service: Mobile tyre checks and fitment services, as demonstrated by service vans in the slide, make tyre management much more convenient. Rather than visiting a service center, customers can enjoy on-site inspections and replacements, saving time and effort. This innovation transforms tyre maintenance into a hassle-free experience and reflects the customer-centric philosophy often associated with Jeff Bezos, which emphasizes identifying customer needs and working backwards from them (Stone, 2007). By integrating these features, the subscription-based model ensures that customers experience tyres as a managed service rather than a product. This transition addresses the key frustrations of the current system while fostering loyalty and satisfaction. Additionally, the incorporation of smart technologies and predictive maintenance enhances safety and performance, while potentially reducing environmental impact, thereby contributing to a more sustainable future for the industry.

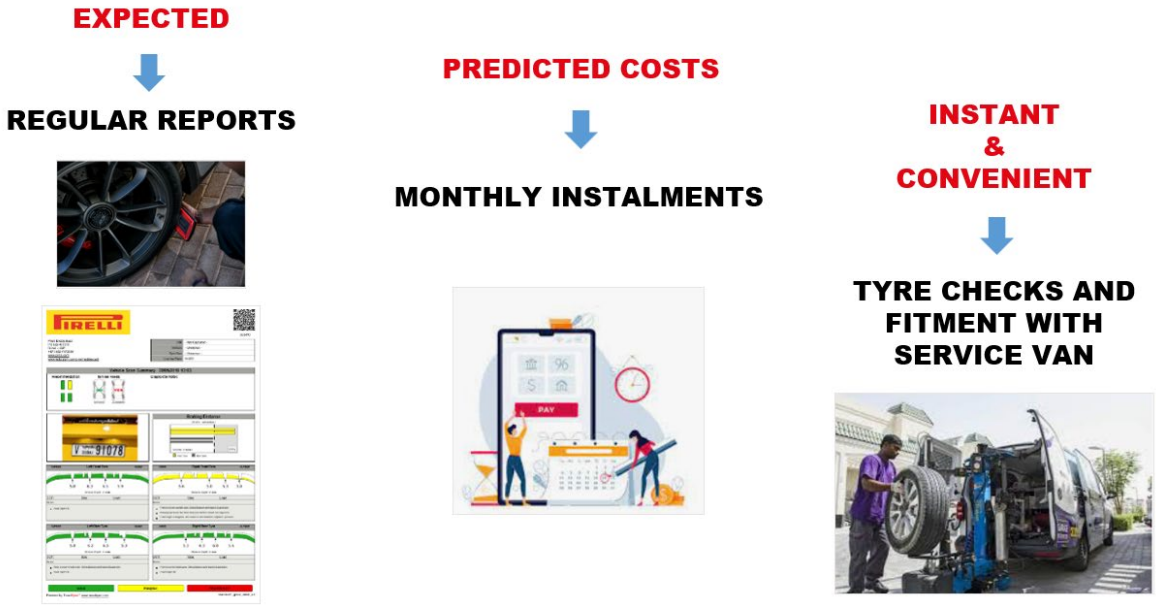


Illustration 4 *Future tyre purchase experience*
Sources: *Own presentation using Google images*

Current Commercial Challenges in Tyre Purchasing

Current tyre purchasing processes are often perceived as inconvenient and unnecessarily complicated. Issues such as unexpected costs, limited availability, and a lack of transparency are common sources of frustration for consumers. Renowned Harvard Business School professor and influential marketing theorist, Theodore Levitt, noted that the true purpose of a business is to create customers and ensure their loyalty over time (Levitt, 1983). Yet, the tyre industry has historically struggled to prioritize customer-centric solutions that address these pain points.

One significant challenge lies in understanding the DOT (Date of Production), which indicates tyre age and can affect safety and performance. Customers often lack clarity about this critical information, which can potentially lead to distrust. Additionally, tyre origin is a frequent concern, as parallel imports – tyres sold outside the manufacturer's intended distribution channel – create further complexity and uncertainty regarding quality and pricing. These issues frustrate consumers and hinder brand loyalty. As the legendary American investor, business magnate, and CEO of Berkshire Hathaway, Warren Buffett, observed it takes 20 years to build a reputation but only five minutes to ruin it (Buffett, 2001). Transparency in these areas is therefore crucial to maintaining trust.

Beyond DOT issues and parallel imports, challenges related to supply chain management can further complicate the tyre purchasing experience. Limited availability and inefficiencies in logistics can lead to delays and inconsistencies, potentially undermining customer satisfaction. Furthermore, issues with certifications and technical compliance – such as ensuring tyres meet local safety standards – can cause additional confusion for consumers and businesses alike. These pain points collectively contribute to the perception of tyre purchasing as a burdensome process. To overcome these challenges, the tyre industry must adopt a customer-centric approach that prioritizes convenience and predictability. This perspective aligns with the legendary British entrepreneur and founder of the Virgin Group, Richard Branson's view, namely that complexity should be avoided, as anyone can make things complicated, but creating something simple is far

more challenging (Branson, 2011). Simplifying the tyre purchasing process by integrating clear communication, transparent pricing, and streamlined logistics may transform customer perceptions of the industry.

Subscription-based models offer an opportunity to address these issues head-on. By shifting the focus from one-time purchases to ongoing service agreements, manufacturers may reduce some of the uncertainties customers face. For instance, tyres could be automatically replaced based on usage data, removing the need for customers to navigate the complexities of production dates, parallel imports, or certifications. As Sam Walton, the American businessman and founder of Walmart and Sam's Club, noted, the true boss of any company is the customer, who can effectively dismiss everyone from the chairman down simply by choosing to spend money elsewhere (Walton & Huey, 1992). A seamless, subscription-based experience ensures that customers feel valued and understood, strengthening their relationship with the brand. Moreover, this model aligns with the growing demand for sustainability and operational efficiency. By ensuring that tyres are replaced only when necessary and that the disposal process is managed responsibly, manufacturers can support environmental goals while also enhancing the customer experience. As John Elkington, a British entrepreneur and sustainability consultant known for developing the triple bottom line concept, said, companies have a duty to take responsibility for the social and environmental impacts of their operations (Elkington, 1997). This dual focus on customer satisfaction and sustainability represents a significant evolution in the tyre industry's approach to serving its customers.

Illustration 5: *Current tyre-related commercial challenges*
Sources: *authors' own presentation using Google images*

The Future of Tyre Management: A Subscription Model

The proposed tyre-as-a-service model revolutionizes the traditional purchasing process by introducing a subscription-based system designed for convenience, efficiency, and customer satisfaction. This model goes beyond simple ownership by incorporating features such as regular tyre checks, automated reports, and predictive maintenance. These innovations not only enhance customer experience but also build long-term loyalty by addressing pain points and delivering

consistent value. As Clayton Christensen, an American academic and business consultant best known for developing the theory of disruptive innovation, noted, the most successful companies are those that do not merely anticipate the future but actively shape it (Christensen, 1997). By embracing this model, tyre manufacturers can position themselves at the forefront of automotive industry innovation. The model begins with a tyre purchase offer that introduces consumers to the subscription service, with the added benefit of enabling registration on platforms like Mypirelli.ae. By uploading the invoice, customers gain access to Big Data that drives predictive analytics for tyre condition monitoring. This enables the provision of tailored services such as complementary tyre reports with timely tyre replacement notifications, ensuring that users are always aware of when their tyres need attention or replacement.

Digital tools, such as Mypirelli.ae, exemplify how technology can drive this transformation. These platforms enable real-time data collection from smart tyres, enabling predictive analytics that optimize supply chains, anticipate customer needs, and improve sustainability efforts. For instance, predictive maintenance can reduce downtime and ensure safety by addressing issues before they become critical. This aligns with the insight of Peter Drucker, an Austrian-born American management consultant, educator, and author, who claimed that the true goal of marketing is to understand the customer so thoroughly that the product or service naturally meets their needs and sells itself (Drucker, 1973). By integrating data-driven insights, tyre-as-a-service platforms can provide tailored solutions that meet individual customer needs seamlessly. A key feature of this service model is mobile tyre fitment services, which eliminate the need for customers to visit physical service centers. As the attached slide demonstrates, tyre fitment with service vans brings the service directly to the customer, making tyre replacement more convenient. This mobile service forms part of a broader initiative to offer Pirelli’s monthly instalment options, easing the financial burden and further improving customer experience.

In addition to enhancing customer satisfaction, the subscription-based model offers operational and environmental benefits. Predictive analytics and streamlined supply chains ensure that tyres are produced, shipped, and replaced only when necessary. By using smart logistics, this model reduces waste by optimizing the distribution and replacement process. This supports the industry's transition to a circular economy, where materials are reused and environmental impact is minimized. As Michael Porter, the American academic known for his theories on economics, business strategy, and competitive advantage, suggested, innovation is the core factor driving economic prosperity (Porter, 1990). The tyre-as-a-service model not only drives innovation but also demonstrates the potential for economic and environmental sustainability to coexist.

The integration of features such as tyre insurance, alongside regular reports and notifications, further ensures customers have complete peace of mind. With continuous monitoring and maintenance, customers need not worry about unexpected costs or safety issues, fostering a relationship built on trust and convenience. The model supports not just individual consumers, but also a broader ecosystem designed to reduce carbon footprints through the integration of recyclable tyres and enhanced sustainability efforts.

In conclusion, the tyre-as-a-service approach represents a paradigm shift for the industry. By integrating digital tools, predictive analytics, and customer-centric services, this model addresses longstanding challenges while paving the way for a future defined by convenience, loyalty, and sustainability. It reimagines tyres not just as products but as part of an interconnected system designed to meet modern demands, ensuring that consumers benefit from a seamless, predictive, and environmentally conscious experience.

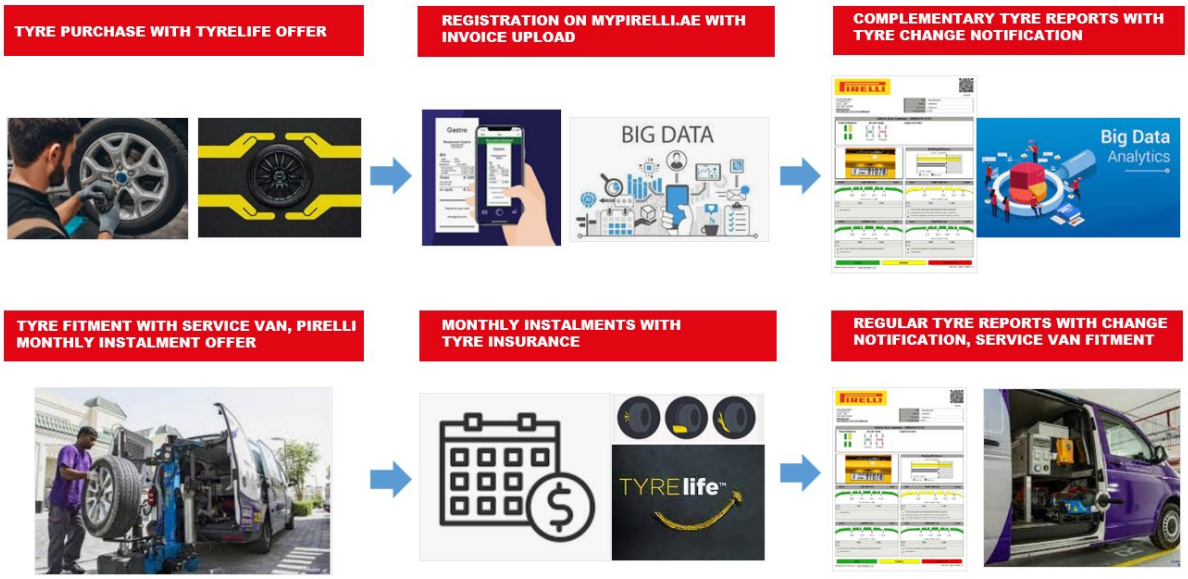


Illustration 6: *Process of the future model*
Sources: *authors' own presentation using Google images*

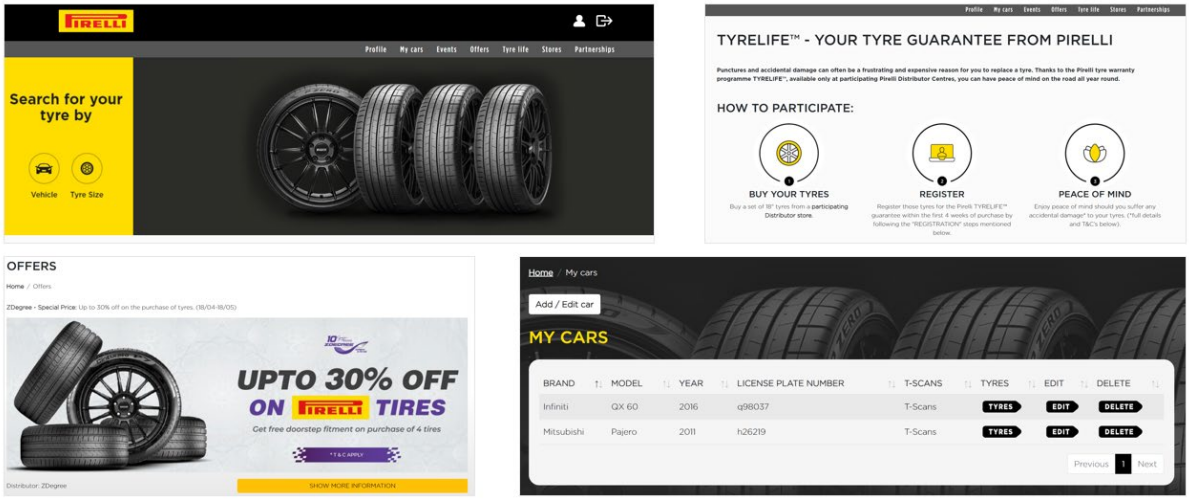


Illustration 7: mypirelli.ae
Source: www.mypirelli.ae

Technological Integration and Supply Chain Optimization

The integration of digital tools into the tyre industry introduces a new era of predictive maintenance and streamlined logistics. Advanced technologies such as tyre scanning systems, IoT-enabled sensors, and automated platforms provide consumers with real-time updates on tyre conditions. These innovations not only improve safety but also extend tyre life, reducing the frequency of replacements and minimizing the environmental impact. Longer-lasting tyres help lower the carbon footprint by using fewer resources, thereby contributing to sustainability and providing financial savings for consumers. As Andrew Winston, an expert on corporate sustainability and green business strategies, aptly stated, turning "green" into "gold" means transforming environmentally

responsible practices into profitable business opportunities, thereby benefiting both the planet and a company's financial performance (Winston, 2006). By reducing waste and conserving resources, the subscription model aligns profitability with sustainability, supporting the industry's environmental goals while benefiting customers.

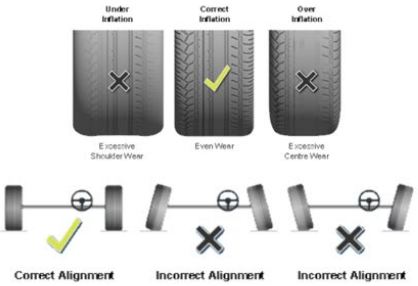
Predictive maintenance is a key feature of this approach, which leverages real-time data to identify wear and tear before it becomes critical. This capability prevents unexpected breakdowns and ensures optimal performance, transforming tyres from reactive purchases into proactive services. Elon Musk, the CEO of Tesla and SpaceX, stressed that the ideal design removes unnecessary parts and processes, as the lightest, cheapest, and most reliable elements are those that simply do not exist (Vance, 2019). Similarly, the subscription model eliminates unnecessary complexities, making tyre management seamless for consumers. Not only does this reduce the inconvenience of tyre care, but it also enhances fuel consumption. Properly maintained tyres, with optimal pressure and condition, contribute to better vehicle efficiency, leading to improved fuel economy. This directly benefits both the environment and the consumer's wallet, providing an added advantage in the form of fuel savings.

For manufacturers and dealerships, the subscription-based model offers significant operational advantages. Using digital tools for smart logistics, forecasting, and production planning enables them to optimize supply chain management, reducing overproduction and excess inventory. This approach reflects the core principles of lean manufacturing, which, as Taiichi Ohno, the chief architect of the Toyota Production System, explained, involve focusing on the entire process from receiving a customer order to collecting payment, and systematically shortening that timeline by eliminating non-value-adding activities (Ohno, 1988). Streamlined logistics facilitated by digital tools can significantly shorten this timeline, improving efficiency and profitability.

Automated platforms also enhance customer engagement by offering subscription models tailored to individual usage patterns and driving conditions. Philip Kotler pointed out that while good companies focus on meeting existing needs, truly great companies go further by creating entirely new markets (Kotler, 2003). The subscription model does exactly this, creating a market for ongoing tyre services rather than one-off purchases, while simultaneously fostering brand loyalty. Customers benefit from complete peace of mind, knowing that their tyres are always in optimal condition, thus reducing concerns about unexpected costs or safety issues.

Finally, these advancements contribute to sustainability by reducing carbon footprints. Optimized supply chains, longer tyre lifespans, and the ability to recycle tyres contribute to reduced extraction and processing of raw materials. As the slide highlights, tyres can be collected and recycled, making the end of a tyre's life part of a broader reuse cycle. John Doerr, a prominent venture capitalist and advocate of goal-setting frameworks such as Objectives and Key Results (OKRs), emphasised that what gets measured is what ultimately gets managed (Doerr, 2018). By leveraging digital tools to track and optimize tyre usage, the industry can effectively manage its environmental impact while delivering superior customer experiences. Focusing on tyre lifespans, waste reduction, improved fuel consumption, and recycling may benefit both the planet and the consumer—resulting in a greener, more cost-efficient experience.

LONGER TYRE LIFE



BETTER FUEL CONSUMPTION

MORE CONVENIENT USER EXPERIENCE

COMPLETE PEACE OF MIND

Illustration 8: *End-user benefits*
Sources: *authors' own presentation using Google images*

LONGER TYRE LIFE

LOWER CARBON FOOTPRINT

GREEN – TYRES CAN BE COLLECTED AND RECYCLED

SMART LOGISTICS

Illustration 9: *Sustainability*
Sources: *authors' own presentation using Google images*

Case Study: Implementing the Subscription Model in the Middle East – Dealership Model

Drawing on practical experience in the Middle East, this section examines how the subscription model can address regional challenges such as market fragmentation, parallel imports, and supply chain inefficiencies. The tyre industry in the region faces significant issues affecting customer loyalty. Data shows that 80% of customers are lost due to pricing, availability, and concerns over tyre origin. As the slide demonstrates, 40% of lost customers cite pricing issues as the reason for leaving, 20% cite availability problems, and another 20% are concerned with DOT and origin (such as tyres being made in China). This information underlines the importance of offering clear, predictable pricing, ensuring availability, and providing transparency about the origin of tyres.

The subscription model addresses these issues by offering customers predictable monthly instalments and streamlined pricing structures, reducing the need for large upfront investments. This approach can mitigate the pricing concerns that contribute to customer loss, making tyre purchases more affordable and less prone to price fluctuation.

Availability issues are also effectively tackled by the subscription model. With regular tyre checks, automated reports, and the convenience of mobile fitment services, customers can be assured that tyres will always be available when needed. As mobile services bring fitment directly to the consumer, availability is no longer dependent on physical stock at service centers, eliminating delays and the common frustration of tyres being unavailable.

Moreover, clarity regarding DOT and origin becomes an integral part of the service offering. By sourcing tyres through approved, transparent channels and providing customers with access to detailed product information, manufacturers can build trust and transparency. This directly addresses concerns about parallel imports and product quality, which may help reassure consumers.

The scalability of the subscription model is evident, especially when tailored to address these regional challenges. In markets where supply chain inefficiencies and fragmented markets are prevalent, digital tools can optimize logistics and ensure timely tyre replacement, thereby improving customer satisfaction and retention. As smart logistics and predictive maintenance become central features of this model, manufacturers and dealerships can streamline their operations, reduce waste, and guarantee product availability.

In conclusion, the subscription model appears well-positioned to solve major challenges faced by tyre consumers in the Middle East, including pricing, availability, and transparency of origin. By providing a service that addresses these pain points while offering a seamless and customer-centric experience, manufacturers can build long-term loyalty and capitalize on a sustainable business model that benefits both consumers and the environment.

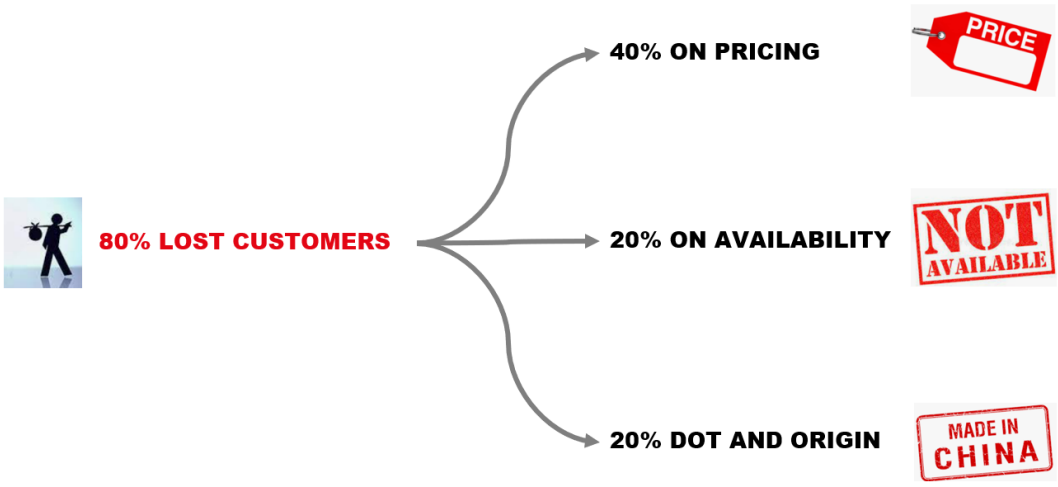


Illustration 10: Impact of the current model on consumer loyalty
Source: authors' own presentation using Google images

Benefits for Customers and Dealerships

The subscription model offers several advantages for both consumers and dealerships. For customers, the key benefits include enhanced convenience, more predictable costs, and extended tyre lifespan, all of which contribute to a better overall experience. The subscription service eliminates the usual inconveniences associated with tyre ownership by simplifying the purchasing process, providing regular tyre checks, and ensuring that tyres are always in optimal condition. As illustrated by the Automated Tyre Usage Data Link, customers receive up-to-date reports on tyre health, enabling them to make proactive decisions to maximize tyre lifespan. Additionally, this model supports sustainability by reducing waste and promoting the recycling of used tyres, helping both customers and dealerships contribute to environmental efforts. The 360-degree end-user interface provided by platforms such as the Garage App also ensures a seamless user experience, by giving customers full access to their tyre data and service history. Customers also enjoy peace of mind, knowing that their tyres are being proactively managed, thereby reducing the risk of unexpected expenses. By integrating automated purchasing behavior data links, the subscription model tailors offers based on individual usage patterns, ensuring that the right tyres are always available at the right time.

For dealerships, the subscription model offers equally significant benefits. One key advantage is smart logistics, which optimizes the supply chain by predicting tyre demand and ensuring that tyres are delivered only when needed. This reduces the risks associated with excess inventory and improves operational efficiency, as supported by real-time data from the automated tyre usage link. The financial side is also positively impacted, as the subscription model enables enhanced financial planning through stable, recurring revenue streams. This approach reduces reliance on large, one-time sales and supports more consistent cash flow, allowing dealerships to forecast revenue more accurately and improve their bottom line.

The model also fosters closer connections with partners, especially tyre suppliers, by building a system designed around the dealership's needs rather than the other way around. This ensures that suppliers are aligned with the dealership's goals, promoting better collaboration and

mutual benefits. As the slide emphasizes, it is the suppliers who depend on the dealership rather than the other way around, thus creating a more balanced and effective supply chain.

Furthermore, the subscription model enables dealerships to expand their services and increase their revenue by offering new subscription plans and engaging with customers in innovative ways. Including tyre insurance as part of the subscription offering, for example, is one way in which dealerships can increase customer satisfaction by providing additional value. These plans generate long-term relationships, increase customer retention, and reduce the inconvenience traditionally associated with tyre replacement. By integrating CRM systems into their operations, dealerships can develop a robust data repository to track and analyze customer preferences, usage patterns, and service needs, thereby improving service offerings and customer satisfaction.

In conclusion, the subscription model offers a win-win scenario for both customers and dealerships. Customers benefit from enhanced convenience, more predictable costs, peace of mind, and improved tyre management, while dealerships gain new revenue streams, better financial planning, and more efficient logistics. This model fosters sustainability, customer loyalty, and stronger partnerships, positioning both parties for long-term success.

Illustration 11: *Subscription-based model commercial advantages*
Sources: *authors' own presentation using Google images*

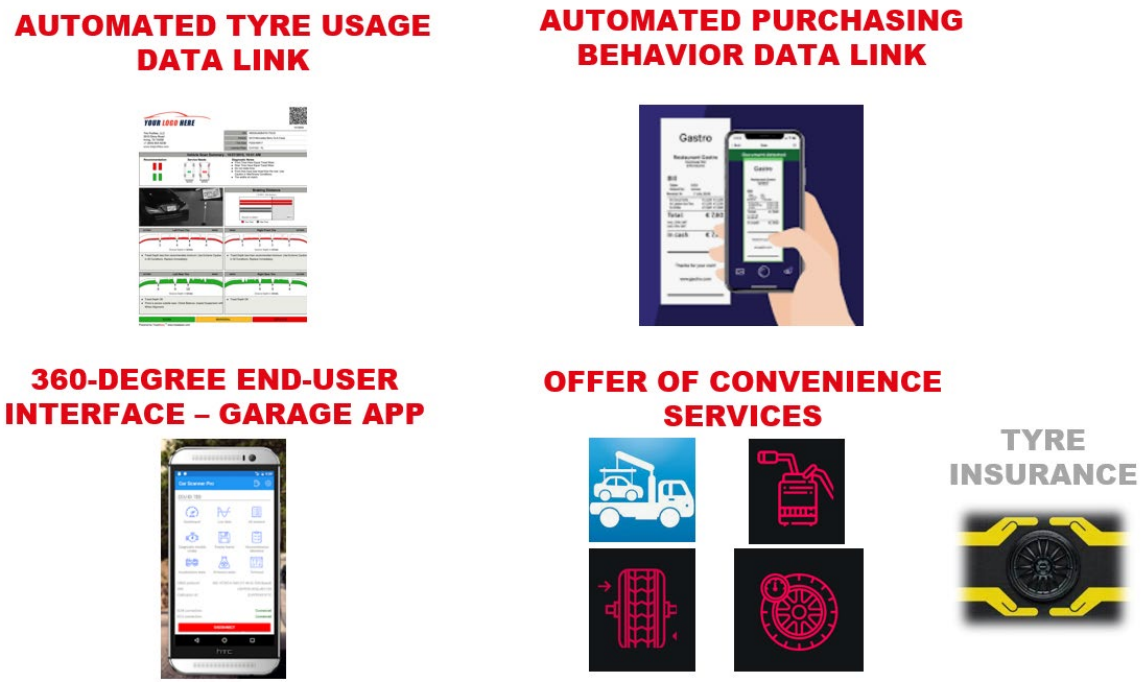


Illustration 12: *Advantages of the digital platform*
Sources: *Authors' own presentation using Google images*

Future Implications and Opportunities

As the automotive industry shifts towards electric vehicles (EVs) and autonomous driving, the tyre-as-a-service model is set to play a critical role in this transformation. Integrating this model into broader service contracts for EVs and autonomous vehicles could provide new revenue streams for manufacturers while offering customers greater value. The move towards EVs, which require specific tyre types and ongoing maintenance, aligns perfectly with subscription models that offer predictable costs and consistent servicing. Furthermore, this model supports the transition to a circular economy, in which materials are continually reused, waste is minimized, and products are designed for longevity. By optimizing tyre lifespan, reducing waste, and ensuring that replacements are based on actual need rather than arbitrary timelines, the tyre-as-a-service model supports the automotive sector's broader sustainability goals.

Conclusion

The tyre industry is at a pivotal moment with the potential to significantly enhance customer satisfaction, loyalty, and sustainability by embracing subscription models. The shift from traditional ownership to a service-based model resonates with broader trends in consumer behavior–where convenience, predictability, and environmental responsibility are increasingly valued. This transformation not only caters to evolving customer expectations but also offers a roadmap for other industries looking to adopt subscription-based or service-oriented approaches.

This paper explored how innovative strategies such as tyre-as-a-service can revolutionize tyre sales and management, ultimately paving the way for a more sustainable and customer-friendly future. By integrating digital tools, predictive maintenance, and automated services, the tyre

industry can create new business models that meet the needs of modern consumers while reducing their environmental impact. As technology develops and the emphasis on customer-centric solutions increases, our approach to tyres will evolve. For consumers, this could mean less stress, greater convenience, and a safer, more sustainable driving experience. For manufacturers, it's an opportunity to reimagine their role—not just as sellers of products but as providers of essential, high-tech services that extend far beyond the initial sale. The question is no longer whether this transformation will happen, but when. Are you ready to embrace the future of mobility?

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