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Special Issue:
Digital Technologies and Innovation

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The *Journal* is published by The Telecommunications Association (TelSoc), a not-for-profit society registered as an incorporated association. It is the Australian telecommunication industry's oldest learned society. The *Journal* has been published (with various titles) since 1935.

Editorial

Special Issues

Leith H. Campbell
Managing Editor

Abstract: This editorial introduces the June issue, which includes a main Special Issue section on Digital Technologies and Innovation, as well as papers from the general submissions. It includes a list of future Special Issues that have been announced.

Keywords: Editorial

Special Issue: Digital Technologies and Innovation

This number of the *Journal* consists mainly of a Special Issue on Digital Technologies and Innovation. This topic was proposed by the Guest Editors, Rim Jallouli, Mohamed Anis Bach Tobji, Gunnar Piho and Hamid Mcheick, through their association with the International Conference on Digital Economy. I would like to thank them for their sustained efforts – and, especially, the leadership of Professor Jallouli – which have brought to publication 12 papers on a wide range of topics related to the digital economy. Their Guest Editorial (Jallouli *et al.*, 2022) provides some context for the Special Issue and an overview of the content.

Elsewhere in This Issue

We also include several papers from our general submissions.

We publish a Special Interest paper, *University Students' Engagement with Devices and Technology: A Comparison of Pre- and Post-COVID-19 Student Use*, and a timely Public Policy paper, *Regional Mobile Telecommunications Access, Competition and Public Benefits*.

In our Telecommunications section, we have one paper: a *Study on Fixed and Dynamic Spectrum Access Models for Cellular Networks*.

In the Biography section, we publish an obituary of John Almgren, a significant industrialist and philanthropist in Australia and a strong supporter of TelSoc (the Telecommunications Association Inc, publisher of this *Journal*).

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Future Special Issues

Guest Editors and Special Issues have a long history with this *Journal* and its predecessor, the *Telecommunication Journal of Australia*. They permit us to widen our perspectives on subjects within the broad scope of the *Journal* and allow us to treat a timely or important topic in greater depth. They have often become our most cited issues and are considered to deliver exceptional value to *Journal* readers.

Two future Special Issues have been announced:

- **AI-Driven Internet Technologies for Future Smart Cities**. Submissions are due by 31 August 2022 and the papers will be published in volume 10, number 4, in December 2022;
- **Women's Participation in the Digital Economy and Digital Society**. Submissions are due by 31 January 2023 and the papers will be published in volume 11, number 2, in June 2023.

Further details are available in the Announcements on the website.

As always, we encourage you to consider submitting articles to the *Journal* and we welcome comments and suggestions on which topics or special issues would be of interest. Feedback on the current Special Issue and each future one would, of course, also be welcome.

Reference

Jallouli, R., Bach Tobji, M. A., Piho, G., & Mcheick, H. (2022). Guest Editorial: Digital Technologies and Innovation. *Journal of Telecommunications and the Digital Economy*, *10*(2), 1–5. https://doi.org/10.18080/jtde.v10n2.590

Guest Editorial

Digital Technologies and Innovation

Rim Jallouli
ESEN, LIGUE, University of Manouba

Mohamed Anis Bach Tobji
ESEN, University of Manouba
LARODEC, University of Tunis

Gunnar Piho
Tallin University of Technology

Hamid Mcheick
University of Quebec at Chicoutimi

Abstract: This editorial comes in three parts: first, an introduction to the collaboration between the International Conference on Digital Economy (ICDEc) and the *Journal of Telecommunication and the Digital Economy*; second, the importance of digital technologies and innovation as a growing multidisciplinary research field; third, a brief introduction to the selected papers in this issue.

Keywords: Digital transformation, Data analytics, Social Media Marketing, Mobile banking, Business Intelligence

Collaboration between ICDEc and the *Journal*

The International Conference on Digital Economy: Emerging Technologies and Business Innovation (ICDEc) is an annual conference that was launched in 2016 by the Tunisian Association of Digital Economy (ATEN) in collaboration with the Higher School of the Digital Economy (ESEN) and the University of Manouba. The ICDEc community has been growing year after year and more partners have joined the project and hosted the conference, namely: Brest Business School in 2018; the International Lebanese University in 2019; Bucharest Business School in 2020 and 2022; and Tallinn University of Technology in 2021. The upcoming conference (the eighth) will be held in the School of Economics and Management, University of Minho, Braga, Portugal, from 2 to 4 May 2023 (https://icdec.aten.tn).

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ICDEc conference aims to debate the theme of the digital economy and targets researchers from a multidisciplinary background. Indeed, the conference covers the fields of computer science, business computing, information systems, artificial intelligence, big data, and knowledge management, as well as business fields such as marketing, finance, human resources and management. In addition to theoretical contributions, the conference welcomes studies with a focus on application contexts like e-commerce, e-business, e-heath, e-learning, digital assets and mobile banking. The six previous proceedings were published in the LNBIP Springer books under the name of *Digital Economy: Emerging Technologies and Business Innovation* (Bach Tobji *et al.*, 2018; 2020; Jallouli *et al.*, 2016; 2017; 2019; 2021).

Thanks to Professor Payam Hanafizadeh, who is a member of the ICDEc program committee, the ICDEc steering committee made contact with Dr Leith Campbell, the Managing Editor of the *Journal* to initiate the project of a special issue on Digital Technologies and Innovation. The objective was to produce a set of focused original papers debating the role of emerging technologies in business innovation in different contexts, such as education, tourism, banking, and insurance. The experience lasted nearly one year and the exchanges among the editorial teams (ICDEc and the *Journal*) were rich and intensive, with the aim of providing the reader of this special issue with a bouquet of original, varied and complementary studies in the field of digital technologies and innovation.

Digital Technologies and Innovation

The digital economy could be represented by three levels: first, a core IT/ICT sector including digital technologies such as IT infrastructures, software and services; second, a set of services and goods derived solely or primarily from the digital technologies, such as collaborative platforms and digital services; third, a broader scope of the digital economy, also called virtual economy or digitalized economy, that concerns the design and implementation of innovative digital business models to produce economic output based on the new paradigm of open innovation, cryptocurrency and shared economy (Bukht & Heeks, 2018). Hence, there is the development of three main domains highly affected by digital transformation: the digital industry, the digital consumer and the digital society.

The pandemic has accelerated the adoption of digital technologies to respond to a new context of unprecedented levels of demand for online consumption, online education, telemedicine services, and the applications of virtual communities. However, the pandemic showed huge digital connectivity gaps based on gender, urban vs rural regions, and in developed vs developing countries (World Bank, 2022). Further research to understand more about the barriers and the scope of the digital economy in developing countries is important to have a global vision of potential international collaboration to reduce such digital gaps.

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This special issue aims to provide the reader with studies related to different contexts and countries, illustrating the diversity of challenges that policy makers and businesses face, especially after the pandemic in developing and developed countries. Some of the newest trends of research in the field of digital economy concern public and private policies for digital transformation, digital financial services for social inclusion, greening digital infrastructure and platforms, engagement on social networks and global communities, and, finally, artificial intelligence and related technologies for efficient decision making.

In This Issue

In line with the trends of research on the digital economy after the pandemic, this special issue presents 12 papers organized into 4 sections. The first section introduces the special issue and debates the topic of digital transformation and global virtual teams. This section consists of two papers focusing on "How to Manage Companies in the Digital Age: Strategic Management Prospects" and "Does National Diversity Impact Conflict in Global Virtual Teams? The Role of Language Factors".

The second section deals with digital technologies and, more specifically, with artificial intelligence for decision-making. Three papers were selected in this area and are entitled as follows: "Enhancing Decision-Making Consistency in Business Process using a Rule-Based Approach: Case of Business Intelligence Process"; "A Secure Attendance System using Raspberry Pi Face Recognition"; and "Effective Optimization of Billboard Ads Based on CDR Data Leverage".

Then, the third section targets the topic of social media and the new trends of digital marketing strategies. Four papers were selected for publication in this section, covering both theoretical and empirical studies and a variety of contexts and regions. The first paper presents a systematic literature review on "Social Media Data Analytics for Marketing Strategies: The Path from Data to Value". The remaining three research papers deal with "Measuring E-Browsing Behaviour and Testing its Impact on Online Immersion", "Measuring Overall Customer Experience in a Hospitality Collaborative Consumption Context: Evidence from Airbnb Users" and "Does Humour Enhance Facebook Users' Responses? Study of the Impact of Humour on Customers' Engagement".

Finally, the last section outlines the increasing importance of digital assets and mobile banking services as drivers for the digitalized or virtual economy. The first paper presents a literature review and a theoretical framework of the technology-enabled personalization for mobile banking services. Then, the last papers study the following topics: "Volatility Behaviour of Bitcoin as a Digital Asset" applied in the context of the South African stock market; and "Fallen into the Chasm: Exploring Mobile Payment Failed Initiative in Lebanon".

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This issue would not have been possible without the cooperation and the continuous support of Dr Leith Campbell, the Managing Editor of the *Journal*. On behalf of the ICDEc community, the guest editors express their appreciation and gratefulness for the valuable guidance that Dr Campbell provided during the entire process of producing this issue, as well as for his relevant contribution to the last two ICDEc conferences as a guest speaker.

The editorial team encourages the readers of this special issue to consider submitting articles to the *Journal* and to the upcoming editions of the ICDEc conference, and welcomes comments and suggestions on potential collaboration for publication in the field of the Digital Economy.

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How to Manage Companies in the Digital Age

Strategic Management Prospects

Olga Stoianova
Saint Petersburg State University, Russian Federation

Tatiana Lezina
National Research University Higher School of Economics, Russian Federation

Victoriia Ivanova
Saint Petersburg State University, Russian Federation

Abstract: The period of high expectations of digital transformation benefits is followed by a period of discussion on strategies and methods for managing digital changes. Not only the rapid development of technology, but also the turbulence of the external environment contribute to the view that traditional approaches to strategic management of the company are irrelevant. Understanding the need to modify classic strategic management methods actualises the task of developing new methodological fundamentals for strategic management. The initial stage of solving this problem is the analysis of the current state of research in this area. This study analyses the Russian research community viewpoints on the prospects of companies' strategic management regarding the digital economy status quo and trends in Russia.

This paper answers the following research questions. What impact does the digital economy environment of Russian companies have on their management systems and what are the prerequisites for changing approaches and mechanisms of strategic management? How do the basic strategic management approaches differ for companies with different experiences, capabilities, and expectations of digital transformation?

The key managerial prospects of the study concern the benefits of various strategic management approaches for companies with different backgrounds, capabilities, and expectations of digital transformation.

Keywords: digital economy, digital transformation of companies, strategic management, Russian companies, prospects of strategic management

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Introduction

Over the past five years, many Russian companies have become involved in digital transformation processes. Despite seeming differences in the interpretation of digital transformation, the majority of authors acknowledge that it is not only technological changes, but also changes in all functional areas of companies. Digital transformation involves "a change in the paradigm of management and business organization based on rapid, flexible and continuous change in interaction with the external environment and within the company" (Nikishova, 2018).

Successful projects are usually implemented by large companies with state participation. The key barrier to digital transformation (KMDA, 2020; KPMG, 2019) is "the lack of a strategy and the resulting internal resistance to transformation". Note that 35% of Russian companies (KMDA, 2020) that have initiated digital transformation do not have a clear strategy for its implementation. Barriers also include a lack of understanding of the benefits and risks of digital transformation projects. Moreover, the rapid development of technology and the need to respond quickly to the turbulence of the external environment form the opinion among scholars and practitioners that strategic management is irrelevant (Kryuchkov, 2017).

Existing and practice-proven management methods and approaches are not fully suitable for managing digital transformation, as they do not take into account the specifics of the process, which involves a comprehensive change in all aspects, including business processes, business value drivers (Kochetkov, 2019), and business models (Orekhova & Misyura, 2020). Thus, the development of an improved methodology for strategic management of companies in the context of digital transformation becomes relevant. The backbone elements of such a methodology could be, on the one hand, the results of generalization and adaptation of the basic concepts of academic research on the subject and, on the other hand, ideas based on the analysis of the best practices of the digital transformation of companies.

The study objective is to analyse the Russian research community viewpoints on the prospects of companies' strategic management regarding the digital economy status quo and trends in Russia. This paper answers the following research questions:

RQ1: What impact does the digital economy environment of Russian companies have on their management systems and what are the prerequisites for changing approaches and mechanisms of strategic management?

RQ2: How do the basic strategic management approaches differ for companies with various experiences, capabilities, and expectations of digital transformation?

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The study materials are the publications in Russian academic journals for the period 2015–2021, dedicated to digital transformation and company management in the new environment, as well as government reports on the digital economy and surveys of consulting companies related to the assessment of the country's digitalization level. The publications are analysed from the perspective of the following topical issues: the impact of transformation on business and management systems; the specifics of digital transformation of Russian companies; and the prospects of the strategic management of companies in Russia.

Design of the Study

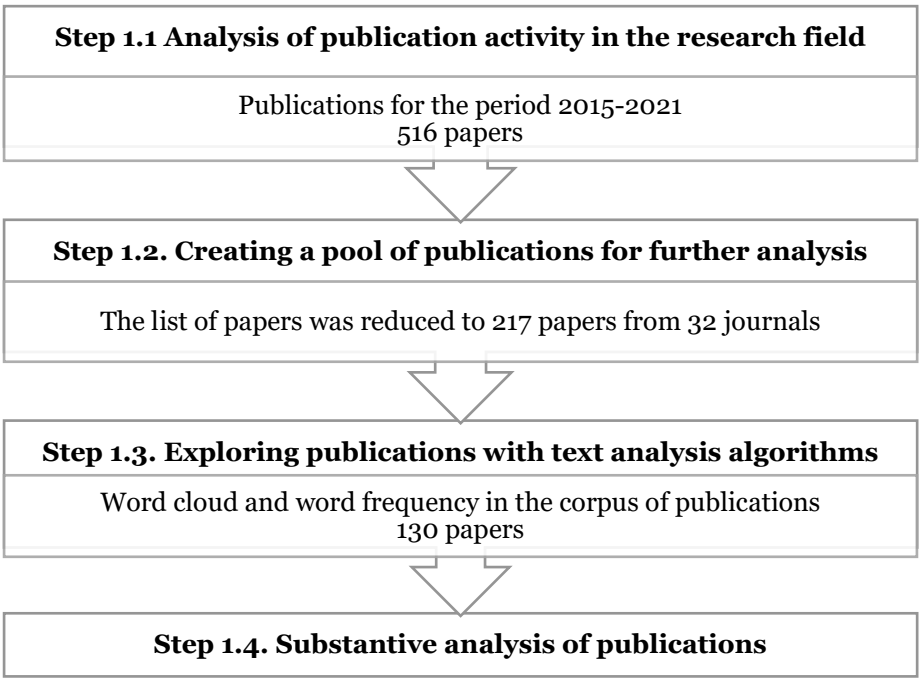

Figure 1. The steps of literature review

To answer the research questions, a study was conducted in accordance with the following stages:

Stage 1. A systematic review of publications

Stage 2. Analysis of the status quo and trends in the digital economy in Russia

Stage 3. Analysis of the environment for the digital transformation of Russian companies and its influence on management

Stage 4. Identification of the strategic management prospects

A systematic review of publications under common accepted standards and recommendations (Rowe, 2014) includes a bibliometric and substantive analysis of works. The main steps of this analysis are presented in Figure 1 and the search strategy in Table 1.

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Table 1. The search strategy

Database	Digital libraries
Scientific field	Economics, Management, Informatics
A pool of keywords for search queries	"digital transformation strategy", "digitalization strategy", "digital transformation management", "digital transformation life cycle", "strategic management" AND "digital transformation", "strategic management" AND "digitalization", etc.
The period of publications	2015–2021
The search is performed in	titles, abstracts, and keywords of the papers

The comments refer to Figure 1.

Step 1.1. Research questions allowed for determining the search strategy for selection sources. The data collection routine was based on queries across the journals and conference proceedings indexed in digital libraries (see Table 2). At this stage, the search procedures were defined according to the areas Economics, Management, and Informatics, using the keywords mentioned in Table 1.

Table 2. Information sources and the articles' distribution

Digital library/Database	Number of journals	Number of articles (total)	Share of selected articles
The Core of the RSCI	20	4830	2.3%
Journals recommended by the High Certifying Commission of RF	30	9640	2%
RSCI	23	7610	2.3%
Scopus	12	3140	1.6%
WoS RSCI	10	2120	2.8%
WoS CC	10	2710	1.2%

As a result, the collected body of papers consisted of 516 publications of different types (see Table 3).

Table 3. Types of publications

Publication type	Share of the total
Literary review	24.1%
Exploratory study	19.6%
Overview	32.1%
Case study	4.5%
Analysis of open statistics	11.6%
Survey results	8.1%

Step 1.2. The papers were screened according to the criteria during the second step of the literature review:

- availability of full text,

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- published in high-ranking peer-reviewed journals: the core of the RSCI, journals recommended by the High Certifying Commission of Russia, Scopus, WoS RSCI, WoS CC.
- publication types: Exploratory study, Case study, Analysis of open statistics, Survey results.

As a result, 217 papers from 32 journals were included in the sample for further analysis.

Step 1.3. Exploring publications with text analysis algorithms

The selected publications formed a corpus of texts for the study. Text analysis algorithms (developed in Python) were applied to identify the main research topics according to the most frequent words. Besides the obviously expected words, the result included such terms as “mechanism” and “model”. Moreover, the term “innovative” was also frequently used, showing that understanding of digital transformation as a method of innovative corporate development is a widespread opinion.

Step 1.4. Substantive analysis of publication texts

The fourth step included a substantive analysis of 130 publications that comprehensively analysed the issues pertaining to the area of consideration.

Finally, it should be noted that owing to space limitations, this article does not list all the references. References may be provided on request by contacting the authors.

Stage 2. At this stage, we analysed the state programs aimed at creating an ecosystem for the country's digital economy, the current results of these programs published in official statistics, and Russia’s position in international digitalisation rankings to identify the status quo and trends in Russia’s digital economy.

Stage 3. To gain an insight into the digital transformation environment of Russian companies and its impact on management, the structure of Russia's economy, the rates of innovation activity, and digitalization indexes in Russia according to her economy’s sectors were investigated.

Stage 4. We explored the theoretical underpinnings of strategic management through an understanding of the digital transformation environment of Russian companies to identify the strategic management prospects and the benefits of various approaches for companies with different backgrounds, capabilities, and expectations of digital transformation.

State of the Art

Substantive analysis shows that changes in the company during digital transformation go beyond the transition to new technologies and concern both the management paradigm and

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business organisation (Choy, 2020; Nikishova, 2018; Orekhova, 2016). The key transformation factors affecting business (Aturin, Moga & Smagulova, 2020; Kergroach, 2017) include the accelerating of the interaction of all participants in the business processes of the company, increasing the potential of intangible capital, implementation of digital platforms, and transformation of space for production and consumption.

An essential result of digital transformation is the development of new forms of business models, primarily the so-called platforms, "radically different from the traditional linear business model, and representing the integration of the main features of organisations and the market" (Kochetkov, 2019; Markova & Kuznetsova, 2019). The type of platform business model affects company strategies. The platforms that focus on consumer-producer interactions shift business values to the areas of network and transaction management. Technological platforms used in the oil, mining, and metal industries substantially improve the production management efficiency by converging informational and operational technologies, implementing an integrated search of resources, data exchange, and raising the level of informational safety (Revenko, 2018). Digital transformation stimulates all kinds of innovations, from technological to organisational, which, in turn, leads to the development of innovation strategies. According to Bek & Gadzhaeva (2018), innovative strategies are considered as transformation strategies depending on the company readiness level and suggested scenarios of change. In the case of the platform business model, an open innovation model, which implies the openness of all business processes, can be considered as a strategy. Note that the range of opinions of different authors on the relationship of business model and strategy varies, from the interpretation (Orekhova & Misyura, 2020) of the business model as an "everyday" strategy to the understanding of the business model as a more general category.

One of the key results of digital transformation is an increase in the capitalization of enterprises and, thanks to spillovers between supply chains, this positive effect also affects related partner companies (Kergroach, 2017). Note that lagging industries and companies lacking the necessary digitalization skills often feel a disproportionately powerful disruptive effect. The latter statement is confirmed by the examples of digital transformation in Russia characterised by uneven IT infrastructure development and significant differences in the degree of company readiness (Zemtsov, Barinova & Semenova, 2019; Lola & Bakeev, 2020).

According to some authors, organisational flexibility and the ability to quickly respond to changes in the external environment, as opposed to the strategic setting to ensure long-term competitive advantage, are currently at the forefront (Götz, 2019; Vaisman, Nikiforova & Nosova, 2019). This requires companies not only to flexibly change all business processes, but also to expand and improve personnel competencies. The mentioned changes require strengthening the role of human resource management and entail the emergence of new forms

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and practices of human capital management, which includes knowledge management, the formation of the company's digital culture, etc. (Ananyin *et al.*, 2018). A special requirement of digital transformation is the extension of the competencies of company managers (Nikishova, 2018), because digital transformation is not simply the introduction of new technologies to support certain production procedures, but essentially the penetration of novel technology into business.

An important consequence of the implementation of digital technology is a change in the organisation of work. For example, in the mining and metallurgical industries, such a consequence is the improvement of working conditions, increasing the level of employee safety by improving the quality of production management, and the ability to take measures to prevent accidents, which, in turn, save the lives and health of workers (Revenko, 2018). At the same time, several industries predict a reorganisation of labour as production activities are integrated into the virtual environment (Krause, 2019). Note that this prediction has now become a reality, especially owing to the COVID-19 pandemic.

A less obvious requirement and effect of the implementation of information technology is the development of ethics and/or a culture of strict compliance in companies, which in turn increases the effectiveness of management (Henriques *et al.*, 2020), as well as the formation of a risk culture. Risk culture is the making of valid decisions based on a qualified analysis of objective relevant information. The volatility of enterprises in the process of digital transformation requires special approaches to management and specialised analytical techniques (Skripkin, 2019). Information becomes a business asset of any company, entailing a change in requirements for the data management system (Stoianova, Lezina & Ivanova, 2020).

The above-mentioned studies provide a common view on the impact of digital transformation on business and management. Identifying the prospects of strategic management requires a comprehensive study of the environment in which digital transformation takes place.

The Digital Economy in Russia: status quo and trends

In 2017, the Russian Federation launched the National Programme, "The Digital Economy of the Russian Federation" (Ministry of Digital Development, 2017), the main goal of which is to create an ecosystem for the country's digital economy. The programme includes the following national projects: Legal regulation of the digital environment; Human resources for the digital economy; Information Infrastructure; Information Security; Digital Technologies; Digital Governance; and Artificial Intelligence.

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The total annual budget of this national programme grew from 1.3 billion USD to 2.1 billion USD in 2021 (Accounts Chamber of the Russian Federation, 2021). The annual national rate of digital spending has grown by 17.3% annually over the past 10 years and reached 2.2% of GDP in 2019. By comparison, global spending in the same category and timescale has grown annually by 10-15%.

The first phase of the programme (2019–2020) resulted in more than 30% of projects failing (Tadviser, 2022). The main reasons for the failures were identified as the digital gap (mostly in access to broadband Internet), the use of corporate platforms unsuitable for work and staff training, gaps in information security, and a highly bureaucratic public administration system within the country. Digital transformation is currently declared one of Russia's national development priorities for the period up to 2030, which is monitored based on four indicators (Abdrakhmanova *et al.*, 2021):

- achieving digital maturity in key sectors of the economy and social sphere;
- increasing the share of mass socially important services available online to 95%;
- increasing the share of households with broadband Internet access to 97%;
- increasing investment in domestic information technology products by four times compared to 2019.

Russia's level of digitalisation can be characterised by the international rankings shown in Table 4.

Table 4. Russia's position in international rankings

Ranking	Russia's place in the ranking	Total
Network Readiness Index (NRI) (measures the level of development of digital technologies and its impact on the economic growth of countries) (2021) (NRI, 2021)	43	121
e-Government Development Index (measures the readiness of countries to implement and use e-government services) (2020) (UN, 2020)	27	194
World Digital Competitiveness Ranking (WDCR) measures the intensity of development and use of digital technologies, leading to the transformation of public administration, business models, and society, assessing how countries manage their competencies to achieve long-term value creation (IMD, 2021)	45	63

Note that the first two indices characterise higher than average levels of e-government, ICT infrastructure, development of digital technologies and their impact on the economic growth of the country. The World Digital Competitiveness Ranking assesses how countries manage

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their competencies to achieve long-term value creation through such factors as Knowledge, Technology, and Future readiness. According to the WDCR, Russia ranks only 38th out of 63 in 2019 (IMD, 2019) and 45th out of 63 in 2021 (IMD, 2021). The Future readiness indicator (42) is affected by the sub-factor "Business agility", by which Russia is only 54th out of 63. Such a poor result is caused by low scores on Opportunities and Threats management (46), Company Flexibility (60), and Knowledge Transfer Management (57)

In many Russian companies, digital transformation is substituted by the implementation of heterogeneous information systems and investments in infrastructure. This is evidenced by the fact that equipment dominates the investment structure of a significant number of organisations, contributing to two-thirds of domestic digitalisation expenditure (Abdrakhmanova *et al.*, 2021). However, in leading economies the limit of economic growth through physical capital has been reached and the new driver of digitalisation is the intangible (digital) assets of companies. All in all, the results indicate a low digital transformation readiness of management systems in many Russian companies.

Since 2021, in the focus of the government's digital economy programmes, there has been a slight shift towards small and medium-sized businesses. For example, under the SME Digitisation Support Programme, companies and entrepreneurs with annual revenues of up to 2 billion roubles (approximately 27 million USD) and a maximum of 250 employees can buy SaaS solutions from Russian developers at a 50% discount (RFRIT, 2022). As part of the implementation of the federal project "Digital Technologies" of the national programme "Digital Economy of the Russian Federation", grant support for projects to develop and implement domestic digital products has intensified (Ministry of Digital Development, 2021). From 2022, a project to support small and medium-sized businesses, based on a digital SME platform, will be launched (The Russian Government, 2021).

The government programmes and projects are expected to boost the digital transformation of Russian business, but success also requires a corresponding effort on the part of companies. To better understand what challenges companies face, it is necessary to analyse the environment for the digital transformation of Russian companies and identify the impact of this environment on management issues.

The Environment for the Digital Transformation of Russian Companies and its Influence on Management

The structure of Russia's economy is characterised by a high share of capital-intensive companies. The top 5 industries contributing to GDP are shown in Figure 2. Among the leaders are manufacturing (including petroleum products manufacturing, chemicals, and chemical

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products manufacturing, metallurgical manufacturing) and mining industries, characterised by long investment return periods (an average of 10-15 years).

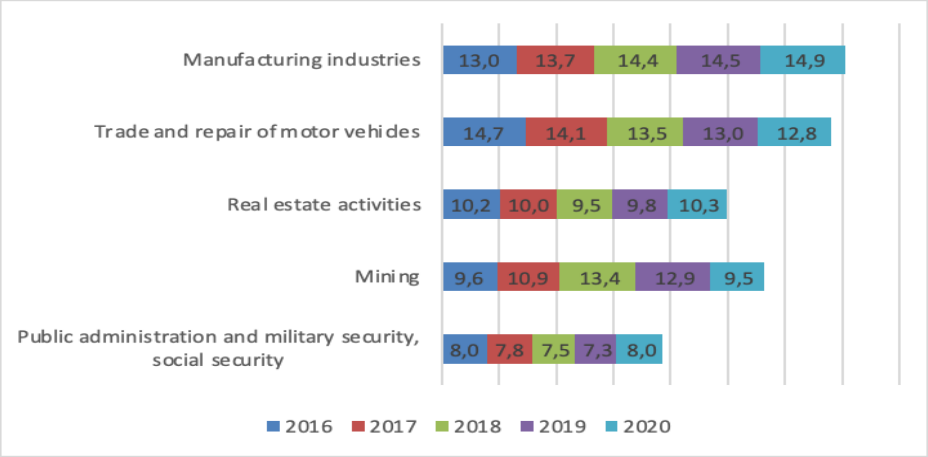

Figure 2. Structure of gross value added in 2016-2020 (a percentage of total)
Data Source: Federal State Statistics Service of the Russian Federation, https://rosstat.gov.ru/

As revealed in the literature analysis, digital transformation is often associated with the innovative development of companies. The highest rates of innovation activity of Russian companies are observed in the manufacturing industries (see Table 5), including sectors with significant asset intensity. Note that companies from these sectors are also very active in implementing digital transformation (Stoianova, Lezina & Ivanova, 2020).

The difference in the level of penetration of digital technologies in various sectors of the economy is illustrated by the digitalisation index developed by HSE IISEZ (Abdrakhmanova *et al.*, 2021). The integral indicator is calculated as the arithmetic average of the shares of organisations adopting each of the digital technologies: broadband Internet, cloud services, RFID technologies, ERP systems, and e-commerce technologies. Industry demonstrates the highest level of digitalization (see Figure 3), primarily due to companies in the manufacturing sectors (Industry) listed in Table 5.

Table 5. Rates of innovation activity in Russia by economic activity sectors (% of innovation-active companies of the total number of companies)

Sector	2018	2019	2020
Manufacturing of computers, electronic and optical products	53.6	49.8	52.4
Manufacturing of machinery and equipment, not included in other groups	45.3	40.9	43.3
Manufacturing of electrical equipment	43.9	41.1	39.9
Manufacturing of motor vehicles, trailers, and semi-trailers	40.5	36.6	36.2
Manufacturing of medicines and materials used for medical purposes	42.7	35.6	33.7

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Sector	2018	2019	2020
Metallurgical manufacturing	31.3	29.0	28.4
Manufacturing of chemicals and chemical products	29.8	26.0	25.9
Manufacturing of petroleum products	31.0	27.5	25.0

Data Source: Federal State Statistics Service of the Russian Federation, https://rosstat.gov.ru/

It should be noted that, in addition to the uneven digitalization by industry, Russia, due to its large scale, is characterised by an uneven intra-industry digitalization across regions. For example, in Industry, the share of organisations (in the total number of organisations) using ERP systems varies by Russian region, from 21.5% in Moscow to 7.7% in the Far Eastern Federal Region, and the percentage of organisations using broadband Internet access varies from 35.7% in Moscow to 5.8% in companies in the Ulyanovsk region (Abdrakhmanova *et al.*, 2021).

As well as the sectoral structure of the Russian economy, there are several other factors that affect the implementation of digital transformation in Russian companies. Features of the environment for digital transformation in Russia highlighted by Russian researchers are given in Table 6.

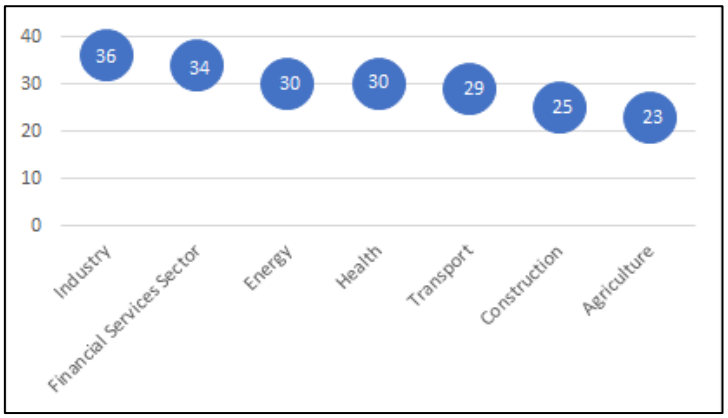

Figure 3. Digitalization indexes for different sectors of the Russian economy
Data Source: Digital transformation of industries: starting conditions and priorities (Abdrakhmanova *et al.*, 2021)

Table 6. Russia's environment for digital transformation

Features of the environment for digital transformation	Authors
The irregular penetration of new technologies	(Zemtsov, Barinova & Semenova, 2019), (Abdrakhmanova *et al.*, 2021)
The bureaucratization of organisational processes	(Eskindarov, 2017), (Kabalina, Makarova & Reshetnikova, 2020)

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Features of the environment for digital transformation	Authors
Large-scale digital transformation projects are mainly implemented in companies with government participation	(Orekhova, 2016), (Ganichev & Koshovets, 2019)
The low level of confidence in the institutional environment, lack of favourable and stable economic conditions in the country	(Lola & Bakeev, 2020), (Nissen, Lezina & Saltan, 2018)
For several industries — inadequate regulatory environment and barriers to Internet commerce, requirements of investors and shareholders to maintain high yields on securities	(Lola & Bakeev, 2019), (Litvinenko & Sergeev, 2019)

According to (KMDA, 2020), Russian companies have realised the importance and benefits of digital transformation, but still more than 25% of the respondents claim that the results do not match their expectations. Many of the mentioned reasons for the failure of digital transformation can be summarised as the poor quality of management. Among the management errors with the most significant consequences are the inappropriate project portfolio and the choice of the wrong transformation strategy.

An analysis of the experience of Russian companies and the results of other authors' studies has highlighted the following features of managing the digital transformation in Russian companies:

- The short planning horizon and expectation of a quick return on investment (Litvinenko & Sergeev, 2019; Nissen, Lezina & Saltan, 2018; Orekhova, 2016). According to the study (KMDA, 2020), with investments up to 50 million roubles (approximately 640,000 USD), most companies expect a payback period of 1-2 years. A major reason for the short planning horizon is the low level of trust in the institutional environment in Russia. Large-scale digital transformations requiring large investments are often unaffordable for Russian commercial companies, so most large digital transformation projects are implemented in companies with a significant share of government funding (Ganichev & Koshovets, 2019), whereas long-term and high-cost investments without state participation are less common (Orekhova, 2016). Now 50 state-owned companies (about 17% of Russia's GDP) are participating in the digital transformation programme, but less than one-third of them have an approved digital transformation strategy or plan (Finam, 2021).
- The focus on improving the operational efficiency of processes (KMDA, 2020; Aturin, Moga & Smagulova, 2020). Many digital transformation projects implemented in Russian companies are aimed at improving operational efficiency, so there has been a tendency towards digitisation of business processes, rather than a comprehensive digital transformation.

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- The lack of digital transformation initiatives from employees. In Russia, a significant deterrent to digital transformation is traditionally bureaucratic organisational structures that not only increase transaction costs, but also impede employee initiative, which is a potential for innovation (Eskindarov, 2017). Note that the early results of the transformation of Russian companies have led to an awareness of the importance of company culture as the basis for stimulating employee motivation and initiative (Kabalina, Makarova & Reshetnikova, 2020).

Required Changes in Strategic Management

The problem of effective strategic management in the context of digital transformation has been widely investigated by many researchers. The strategic management prospects identified by Russian authors are summarised in the study (see Table 7).

Table 7. Russian authors' viewpoints on strategic management prospects

Strategic management prospects	Authors
Implementation of situational management as an alternative to strategic management	(Ananyin *et al.*, 2019), (Bauer, Zatsarinny & Ilyin, 2018)
Strategic management with a focus on technological innovations and the forming of ecosystems	(Komkov & Kulak, 2018), (Litvinenko & Sergeev, 2019), (Polunin & Yudanov, 2020), (Zhuravlyov, Varkova & Zhuravlyov, 2020), (Zhuravlyov & Varkova, 2018)
Implementation scenario-based strategic management	(Bratchenko, 2017), (Kryuchkov, 2017), (Kuzin, 2016), (Marshev, 2016), (Vaisman, Nikiforova & Nosova, 2019)
Focusing on results that do not directly benefit the company	(Bratchenko, 2017), (Zhuravlyov, Varkova & Zhuravlyov, 2020), (Zhuravlyov & Varkova, 2018)

There is a viewpoint that strategic management is not effective in today's rapidly changing world. According to Ananyin *et al.* (2019), digital transformation requires a radical reduction in the time to solve management tasks, which justifies management on a real-time scale. The rationale for this kind of management is the increasing flow of incidents and abnormal situations, the complexity of a company's information model, and other factors. Situational management in its traditional version (Zatsarinny, Ilyin & Kolin, 2017), or in an adapted version (Bauer, Zatsarinny & Ilyin, 2018) is proposed as an alternative to strategic management.

There is an alternative point of view concerning the growing role of strategic management of companies in the conditions of digital transformations. In Polunin & Yudanov (2020), it is noted that the rapid growth of companies (average annual revenue growth of 27% and higher)

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over the long term is only possible with strategic management, which is expressed in "subordination of current activities to the goals of preparing future growth". An important role of strategic management for companies with high capital intensity is highlighted in the paper Litvinenko & Sergeev (2019). It notes that, over recent years, companies in the sector have prioritised "short-term challenges, such as reducing costs and improving the profitability of existing assets". Many companies have reduced capital expenditure and cut exploration budgets, which, according to the authors, "may have a negative impact on the mineral resource base of leading mining companies in the near future and cast doubt on the prospects for their long-term development". The authors of the article Litvinenko & Sergeev (2019) refer to technological innovation, the importance of which, for mining companies, is also noted in Komkov & Kulak (2018), Zhuravlyov, Varkova & Zhuravlyov (2020) and Zhuravlyov & Varkova (2018), as well as the formation of an industry ecosystem, as the main tools for the strategic growth of companies.

The concept of scenario management (Marshev, 2016) is aimed at balancing strategic and tactical management. One of the key ideas is to move away from micro-management towards management under conditions of so-called "manageable chaos" (Kryuchkov, 2017; Kuzin, 2016). However, the high cost of errors at the strategic level leads to the desire of company management for complete order and control. To overcome this contradiction, an established methodological framework is needed that allows companies to switch from one scenario to another when the assumptions change (Vaisman, Nikiforova & Nosova, 2019). Otherwise, it is only a question of scenario planning at the strategic management level (Bratchenko, 2017). In addition, as noted in Kuzin (2016), the growth of available information and knowledge does not lead to an increase in the ability to accurately predict the future. To solve this problem, Kuzin (2016) proposes the use of process and non-linear thinking in management decision-making. The latter is explored in one of the relatively new strands of managerial thought, "nonlinear strategic management" by Heinrich Lemke. The additional complexity of strategic management is associated with the active implementation of the ideas of sustainable development and corporate social responsibility in Russian companies (Zhuravlyov, Varkova & Zhuravlyov, 2020).

The results of a synthesis of different views on strategic management prospects can be generalized from the point of view of practical usage (see Table 8).

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Table 8. Strategic management prospects: benefits for practice

Strategic management prospects	Beneficiaries
Implementation of situational management	Companies with a quick return on investment and low capital intensity
Strategic management with a focus on technological innovations and formation of ecosystems	Companies of fuel, energy, and mineral resource industries
Implementation scenario-based strategic management	Manufacturing companies, especially mechanical engineering ones
Focusing on results that do not directly benefit the company	Companies, which follow the principles of corporate social responsibility

Implementation of situational management in its traditional or in an adapted version is relevant for companies with a quick return on investment and low capital intensity (first — for IT companies). Strategic management with a focus on technological innovations and forming of ecosystems is significant for companies of fuel, energy, and mineral resource industries.

Implementation scenario-based strategic management is relevant for manufacturing companies, especially mechanical engineering ones. In this regard, many authors point to an urgent need for a methodology that allows companies to switch from one scenario to another when the context changes. Otherwise, it is only an issue of scenario planning within strategic management. And last but not least among the strategic management prospects is focus on results that do not directly benefit the enterprise due to the active implementation of the ideas of sustainable development and corporate social responsibility in companies.

Conclusion

To identify the prospects of strategic management of digital transformation in Russian companies, a comprehensive study of the environment in which this transformation takes place was performed. Governmental support for the development of the digital economy is found to have ensured high digital maturity in many areas, such as e-government, social services, and ICT infrastructure. The digitalisation level of business varies greatly within the economy's sectors, a company's scale, and the share of government funding. However, the results of this study indicate a low digital transformation readiness of management systems in many Russian companies.

The main theoretical contribution of the study concerns the prerequisites for changes in strategic management approaches and mechanisms revealed by assessing the impact of digital transformation on business and company management systems. It was proven that, for countries where the share of capital-intensive industries is high, abandoning strategic management is impossible and can lead to disastrous consequences. It is, therefore, necessary to move away from using only short planning horizons and the expectation of quick results. At

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the same time, increasing uncertainty in all areas requires the adaptation of existing strategic management mechanisms.

The key managerial prospects of this study concern the benefits of various approaches for companies with different backgrounds, capabilities, and expectations of digital transformation. For the companies with a quick return on investment and low capital intensity, the implementation of situational management is preferable. Strategic management, with its focus on technological innovations and forming of ecosystems is significant for companies within the fuel, energy, and mineral resource industries. Moreover, as these companies follow the principles of corporate social responsibility, mechanisms and methods should be used to incorporate indirect benefits into strategic decision-making. Scenario-based strategic management is relevant for manufacturing companies, especially mechanical engineering ones.

This study also has certain limitations. The research provides some managerial insights but does not cover a mechanism for improving the strategic management of companies in the context of digital transformation. Future research perspectives involve analysing and developing strategic management mechanisms, methods, and tools adapted to different types of beneficiaries.

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Does National Diversity Impact Conflict in Global Virtual Teams? The Role of Language Factors

Ana Maria Soares
University of Minho and CICS.NOVA.UMinho, Braga, Portugal

Robert Stephens
Shippensburg University of Pennsylvania, Shippensburg, USA

Longzhu Dong
University of Wisconsin-Eau Claire, Eau Claire, USA

Abstract: This study looks at the impact of national diversity on task and relationship conflict in the context of global virtual teams (GVTs). We investigate the interaction effects of both English skills and openness to linguistic diversity on these relationships. We administered a questionnaire to 283 GVTs working on a collaborative experiential learning project to develop an international business plan. Our results show that, for teams exhibiting high levels of openness to linguistic diversity and high levels of English skills, increased levels of national diversity on the team are associated with lower levels of task and relationship conflict. The relationship is reversed, however, in teams where openness to linguistic diversity and team English skills are low. These findings shed light on the relationship between national diversity and conflict by suggesting that both English skills and team attitudes toward language diversity are important in reducing conflict. Moreover, openness to linguistic diversity may be more important in reducing conflict than the level of team members' language proficiency.

Keywords: GVTs, National diversity, Conflict, English skills, Openness to linguistic diversity

Introduction

The mechanisms of globalization have led to a dramatic increase in the number of multicultural/multinational teams, including global virtual teams (GVTs), in recent decades (Gonzalez-Perez *et al.*, 2014; Rowell, 2016). GVTs are defined as "culturally diverse and globally dispersed virtual teams" (Glikson & Erez, 2020, p. 1). This trend has increased with the worldwide COVID-19 pandemic, leading to the nearly ubiquitous use of virtual teams within organizations both large and small in both domestic and international settings. Hence, the value of better understanding variables which impact both GVT processes and performance continues to grow in importance.

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Team member diversity, consisting of differences in either nationality and/or culture, has been the object of substantial research in international business and other disciplines. National diversity is a particularly relevant type of diversity as businesses and organizations operate across multiple countries.

Of particular interest is assessing how team diversity impacts the process and output of team work, including communication, exchange of task relevant information, task and relationship conflict, team creativity and performance. In general, these diverse streams of research find that the effect of diversity on team effectiveness can be either positive or negative (van Knippenberg, van Ginkel & Homan, 2013; Ayub & Jehn, 2011). A number of studies find that increased diversity is associated with declines in team communication, functioning and dynamics, as well as increases in both relationship and task conflict (Homan *et al.*, 2007; Kankanhalli, Tan & Wei, 2006; Shachaf, 2008). Stahl *et al.* (2010), in their thorough meta-analysis of team cultural diversity, find that increases in team diversity are associated with both process losses through increased task conflict and decreased social integration. On the other hand, the authors also find that increasing diversity levels lead to process gains through enhanced creativity and satisfaction. No direct effect between diversity and performance is found, but the authors call for further research examining multiple moderators of relationships between diversity and both contextual and process variables. This highly influential paper was awarded the 2020 JIBS Decade Award and is widely cited in the literature. More than ten years later, however, very little progress has been made in clarifying the input-process-output logic of the "double-edged sword" of cultural diversity (Minbaeva, Fitzsimmons & Brewster, 2021). The current study endeavours to address this deficit by examining two potentially important language-related factors that could moderate the impact of diversity in GVTs. — proficiency in the language of group communication and openness towards language diversity. This builds on previous work which finds that linguistic difficulties of members of multilingual GVTs may negatively impact effective communication within the group and hinder the interpersonal relationships and group dynamics, especially the formation of a shared understanding within the group (Fleischmann, Folter & Aritz, 2020).

After a comprehensive review of the literature, we have identified three significant gaps. First, existing studies view language exclusively as a skill residing in individuals or as a social marker that serves as a basis for subgroup formation. We recognize the possibility that language skills also exist at the group level and can be measured as a collective phenomenon, rather than exclusively at the level of the individual. Second, many of the existing language-focused research studies at the group level highlight language diversity and do not measure group level common language skills. In addition, the results of these studies are mixed and inconclusive. Some support the association between language heterogeneity and negative group processes

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(Stahl *et al.*, 2010), while others fail to establish this link (Tenzer, Terjesen & Harzing, 2017). Third, research on diversity mindsets is lacking, especially the mindset referred to as group openness to language diversity. The inconsistency in findings of previous studies may be due to the fact that negative team outcomes are explained not by diversity itself but by group levels of openness or commitment to difference (Shrivastava & Gregory, 2009).

To fill these gaps in the literature, this study focuses on the team level of analysis and explores how language skills and openness to linguistic diversity can moderate conflict in diverse teams.

In this paper, we will first develop a conceptual framework based on four key variables as evidenced in GVTs: 1) national diversity; 2) conflict; 3) team skills in a common language (in this case, English); and 4) openness to linguistic diversity. We develop a research model in which we hypothesize the relationships between these variables, with openness to linguistic diversity and English skills serving as moderators to the central relationship between national diversity and task conflict. We test this model using a large dataset derived from 283 GVTs. Results of the analysis are discussed and implications for practice as well as directions for future research are explicated.

Conceptual Framework

National diversity

According to Ayub & Jehn (2018, p. 616), "[d]iversity refers to differences with respect to a common attribute used as the basis to perceive oneself to be different from another". Since global teams have members from different national, cultural and linguistic backgrounds, they are usually very diverse on several dimensions. Given the growing number of companies and organizations operating across borders, we focus on national diversity, defined as differences in the home countries of the GVT members.

As highlighted by Jimenez *et al.* (2017), this diversity constitutes a potential strength for GVTs compared to more localized teams as it may improve problem-solving skills and boost the creativity of teams (Kankanhalli, Tan & Wei, 2006). This optimistic view of diversity's positive effects in decision making has been challenged, however, by studies describing negative effects of diversity in team communication, functioning and dynamics (Homan *et al.*, 2007; Shachaf, 2008). In particular, in the negative impacts that increasing levels of diversity have on teams, cohesion and conflict communication have been noted (Kankanhalli, Tan & Wei, 2006).

Several theoretical frameworks are useful in understanding the effects of team diversity on team outcomes, including the categorization-elaboration model and the concept of diversity mindsets. The categorization-elaboration model holds that there are positive and negative

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effects of each type of diversity (Ayub & Jehn, 2018). The positive effect refers to information processing, while the negative effect is related to social categorization. According to the positive view, similarities among team members in knowledge and skills leads to improved team outcomes. On the contrary, diversity manifested as interpersonal differences and intergroup biases (the social categorization perspective) has a negative impact on team outcomes. This suggests a process-content distinction in terms of team functioning. Team dynamics related to process are more exposed to impacts from misunderstandings based on differences in cultural norms and values, while content-related issues would be less impacted by the negative effects of diversity and instead would benefit from the different skills, perspectives, and capabilities of diverse team members.

Conflict

There are several obstacles to working in GVTs. In particular, coordination and communication may be challenging as team members may not agree on how to collaborate (Wakefield, Leidner & Garrison, 2008). The potential for lack of agreement is enhanced by the geographical, cultural, temporal and technological distance (Scott & Wildman, 2015). This disagreement may lead to team conflict (Jimenez *et al.*, 2017; Ayub & Jehn, 2011).

The literature on intragroup conflict has focused on two main types of conflict: relationship conflict and task conflict. Relationship conflict refers to interpersonal disputes and incompatibilities, while task conflict refers to lack of agreement over different options regarding the group tasks (Dechurch & Marks, 2001; Simons & Peterson, 2000). Task conflict may involve questions related to members' roles, the allocation of tasks to team members, and the responsibility levels that should be allocated to each member (Kankanhalli, Tan & Wei, 2006). Negotiating task assignments and creating a common understanding of mutual and individual responsibilities within a team is a process-focused activity. As previously discussed, the categorization-elaboration model would indicate that process-oriented variables are more likely associated with the negative impacts of diversity. Specifically, the categorization process related to diversity can increase intragroup conflict (Ayub & Jehn, 2011). Task conflict may impact teams' abilities to effectively accomplish their goals and could lead to inefficiencies and misunderstandings within the team.

Prior research has noted that, along with geographic distribution, team member diversity is most often an antecedent to conflict (Kankanhalli, Tan & Wei, 2006; Scott & Wildman, 2015). National diversity may create informational and interpersonal distance, which makes the possibility of task conflict more likely. According to Ayub & Jehn (2011, p. 254), "outgroup disagreements are often expected in diverse groups and opinion differences with the outgroup

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members are accepted because they are congruent with the expectations of being different". Hence, the following hypothesis is proposed:

Hypothesis 1a. National diversity positively impacts task conflict.

Similarly, cultural diversity may contribute to relationship conflict (Kankanhalli, Tan & Wei, 2006). Communication challenges resulting from different values, beliefs and language backgrounds as well as other factors associated with the nature of collaboration in GVTs, may lead to misunderstandings and trigger tension and friction among group members.

Hypothesis 1b. National diversity positively impacts relationship conflict.

English skills

Researchers have been keen to acknowledge the importance of communication and language use within multinational corporations (MNCs) in recent years (Lauring & Selmer, 2012). In general, research in this area recognizes the impact of language on both a) companies' abilities to pursue their strategies consistently across borders (Karhunen *et al.*, 2018) and b) the performance of multinational groups and teams (Fleischmann, Folter & Aritz, 2020). English is often the mandated language of global business and international projects; hence we focus on English skills.

While the study of language in international business has grown into a rich field of study, we focus on the role of language (English in our case). A systematic literature review of language issues in international management has uncovered three main categories of assumptions about language in research in this area: language as a top management problem; language as an individual characteristic of MNC employees; and language as a social practice in MNCs (Karhunen *et al.*, 2018). The first category highlights the existence of different languages in use within organizations and teams as posing a problem for communication. Given the prominence of English as an international business language, it is also often the working language in MNC and global teams, but differences in English proficiency among organizational participants can be quite pronounced. Studies within this perspective have also looked at linguistic competence, with an underlying view that improving language skills contributes to overcoming communication barriers. In what concerns category 2, a focus on the negative implications of languages (e.g., social categorization and ingroup-outgroup divisions) is dominant.

The negative implications of language seem to have dominated research in the area (Karhunen *et al.*, 2018). Research has found that differences in language proficiency impairs knowledge sharing (Presbitero, 2020). Language matters also for group dynamics. Neeley (2013) found that non-native speakers of English resent and distrust their native English-speaking co-workers.

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In virtual teams where communication is often conducted through lower context means, such as email and text messages, and/or asynchronously, the challenges of subpar language proficiency can be even more acute due to truncated contextual clues (Barner-Rasmussen & Aarnio, 2011, Daim *et al.*, 2012). Tenzer, Terjesen & Harzing (2017, p. 816) argue that language "constitutes the foundation of knowledge creation", as a shared language is required for interpreting, understanding, and responding to information (Lauring & Selmer, 2012; Klitmøller & Lauring, 2013). Language is also instrumental for social interaction and developing a shared group culture and identity. Hence, being able to communicate smoothly in a shared language will likely contribute to effective knowledge sharing (Klitmøller & Lauring, 2013) and thus reduce the informational distance in GVTs. Based on these findings, we expect that English skills function as a moderator of the positive impact of diversity in task conflict, specifically:

Hypothesis 2a. Team English skills moderate the relationship between national diversity and task conflict in GVTs, such that better English skills weaken the positive impact of national diversity on task conflict.

Hypothesis 2b. Team English skills moderate the relationship between national diversity and relationship conflict in GVTs, such that better English skills weaken the positive impact of national diversity on relationship conflict.

Openness to linguistic diversity

The concept of diversity mindsets has been developed as an extension of diversity theory (Van Knipperberg *et al.*, 2013). According to these authors, the team's mental representation of the team's diversity is the key to understanding the impact of differences among team members. This perspective differs from other theories of diversity since it argues that it is not the actual diversity of teams that impacts outcomes, but the openness of team members toward diversity that influence outcomes. For example, Minbaeva, Fitzsimmons & Brewster (2021) found that a diversity mindset moderates the effect of diversity in performance, so that the dual outcomes of diversity depend on whether the team climate is favourable to diversity.

This introduces an important attitudinal aspect to diversity that is rarely examined. In this study, we are particularly interested in the impact of linguistic diversity on team functioning. The diversity mindset perspective suggests that it is not just differences in linguistic abilities among team members that will impact team outcomes, but also the attitude of team members toward those differences. Thus, we propose that openness to linguistic diversity will have a moderating effect on the central relationship between national diversity and task conflict.

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Openness to linguistic diversity is a dimension of diversity climate that refers to the acceptance of team members' differing language proficiency (Lauring & Selmer, 2012). GVTs rely on a common working language for communication; however, group members may have differing levels of proficiency. These differences may affect in-group communication, but the attitudes of team members toward these differences may be equally, if not more, important than the differences themselves.

Working with people at different levels of common language proficiency requires being willing to clarify and restate when understanding appears limited. Team members with low openness to linguistic diversity are less likely to display these communication-facilitating traits and behaviours. When team members are more tolerant to linguistic diversity, however, the benefits of information sharing from people with varied perspectives are likely to be magnified. Therefore, we hypothesize:

Hypothesis 3a. Team openness to linguistic diversity moderates the relationship between national diversity and task conflict in GVTs, such that higher openness to linguistic diversity weakens the positive impact of national diversity on task conflict.

Hypothesis 3b. Team openness to linguistic diversity moderates the relationship between national diversity and relationship conflict in GVTs, such that higher openness to linguistic diversity weakens the positive impact of national diversity on relationship conflict.

We are proposing an additive multiple moderation model among the predictors. We expect that there is an interacting effect of team members' language skills and openness to linguistic diversity on the relationship between national diversity and task and relationship conflict. According to social identity theorists, in GVTs, language not only serves as the medium of interaction but, more importantly, it also serves as a social marker by which individual differences/similarities are identified (Giles & Byrne, 1982). Although GVT members may use a common language, in teams with lower openness to language diversity, non-native-common-language speakers' language fluency and accents are likely to become more noticeable and could result in the formation of social barriers, which are then manifest in increased conflict. We argue that team members' language skills and tolerance to language dissimilarities are equally important. Effective skills in the team's common language provide GVTs a high-quality communication medium. In addition, team members' openness towards language differences can lead to a more supportive climate in the team, which then further reduces any conflict that may emerge as a result of language and other forms of national diversity. This relationship is born out in the literature. McMonagle (2010) found that teams exhibiting intolerance for variations in spoken language experience higher levels of conflict and mistrust.

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Therefore, we hypothesize:

Hypothesis 4a. The positive relationship between national diversity and task conflict is strongest when both English skills and openness to linguistic diversity are low, and lowest when they are both high.

Hypothesis 4b. The positive relationship between national diversity and relationship conflict is strongest when both English skills and openness to linguistic diversity are low, and lowest when they are both high.

Research Model

We present the research model depicted in Figure 1 based on the theory and hypotheses presented above.

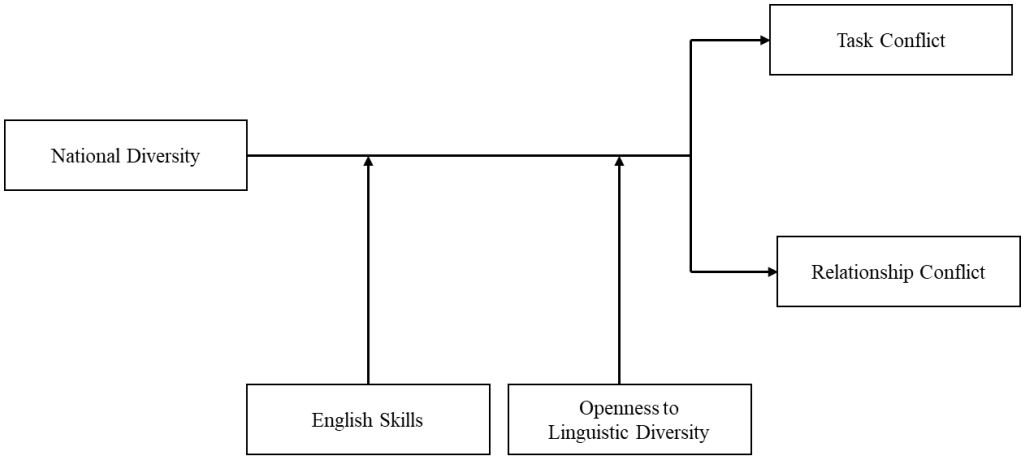

Figure 1. Research Model

Method

A quantitative approach has been followed to evaluate the proposed model. Hypotheses are tested using the data from the X-Culture Project.

Data collection

For the present study, we use data from X-Culture, a large-scale international experiential learning project involving over 6,000 MBA and bachelor's level business students from 150 universities in about 40 countries. The project involves the development of a solution to real-life business challenges presented by actual companies from around the world. Students are assigned to global virtual teams and work for about 8 to 10 weeks. The task includes market research, market entry plan development, and product design. All communication regarding project instructions and parameters is provided online and in English. The project is supervised by instructors with rich business consulting experience and managed as a regular

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business consulting project. During their participation in the project, team members answer a survey about their experience.

Questionnaire

The measures used in the survey are previously validated scales sourced or adapted from the literature as follows.

National Diversity. All students indicated their home country. To calculate team level national diversity, we used a formula developed by Tsui, Egan & O'Reilly (1992):

$$D = \sqrt{1 / n \sum_{i}^{n} (S_i - S_j)^2}.$$

This measure represents the square root of the summed square differences between individual S_i values of a specific demographic variable (in this case, home country as indicated by each student) and the value of the same variable for every other individual S_j in the sample for the work unit, divided by the total number of respondents in unit (n), in this case the syndicate group (Tsui, Egan & O'Reilly, 1992).

Conflict. Task and relationship conflict were assessed using a five-point Likert three-item scale inspired by Jehn (1995). Table 1 details the items used in the questionnaire. The Cronbach's alpha for task conflict is 0.893 and for relationship conflict is 0.880.

English Skills. Team English proficiency was measured using the average of each team member's self-reported English skill level on a scale from 1 (poor) to 5 (excellent) (Table 1). Using self-reported levels of language proficiency is in line with other studies in this area (Jehn, 1995; Erez *et al.*, 2013).

Openness to Linguistic Diversity. Openness to linguistic diversity was assessed by a four-item scale adapted from Lauring & Selmer (2012) (Table 1). The Cronbach's alpha was 0.600 with all four items. After a closer inspection, we removed the last item due to its low loading on the construct (0.051), possibly due to the reverse coding of the item. The Cronbach's alpha of the abbreviated three-item scale is 0.824.

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Table 1. Operationalisation of Variables

Variables Author	Items used in the questionnaire
Task conflict Jehn (1995)	How much conflict of ideas is there in your work group? How frequently do you have disagreements within your work group about the task of the project you are working on? How often do people in your work group have conflicting opinions about the project you are working on?
Relationship Conflict Jehn (1995)	How much relationship tension is there within your work group? How often do people get angry in your group? How much emotional conflict is there in your work group?
English Skills	How would you describe your ability to understand spoken English? How would you describe your ability to understand texts written in English? How would you describe your ability to speak English? How would you describe your ability to write in English?
Openness to Linguistic Diversity Lauring and Selmer (2012)	My team members enjoy working with other people on the team despite language barriers. My team members make an extra effort to listen to people speaking different languages. My team members are eager to learn from people even when communication is slowed down by language barriers. My team members are more reluctant to communicate when faced with people speaking a different language.

Controls. We have considered team size, percentage of male teammates on a team, and readiness test score (a pre-project test for students' readiness to participate in a global virtual team) as control variables.

Analytical approach

To analyse the effects of the moderating effects of both English skills and openness to linguistic diversity on the relation between diversity and conflicts, we performed additive moderation analysis using PROCESS SPSS Macro version 2.13, model two, created by Hayes (2017). All the variables that define the interaction terms were mean centred. The conditioning values were one standard deviation below the mean (Low) and one standard deviation above the mean (High). Following Hayes (2017), a bootstrapping approach with 5,000 samples was used to determine the significance of all the effects at 95% percentile confidence intervals, and the estimated effects were reported as unstandardized regressions coefficients.

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Results

For this study we used data from the X-Culture survey which was applied to all the teams that participated in the project in the Fall of 2018. Our database includes data from 283 GVTs (1,191 students) with an average team size of 4.21, on average 43% males on a team. and average age of 22 years old; 88% of the participants are undergraduate students, and 12% have a master's degree. Most students (81%) have at least 1 year of work experience. These students are from 45 different countries. Table 2 reports the means, standard deviations, and correlations of the studied variables.

Table 2 Means, standard deviations, and correlations

	Mean	S.D.		2	3	4	5	6	7
1. Team Size	4.214	0.643							
2. Male Percentage	0.427	0.251	0.022						
3. Readiness Test	85.860	4.991	-0.070	-0.037					
4. Diversity	0.872	0.069	-0.060	-0.115	.271**				
5. Openness to Linguistic Diversity	3.854	0.457	-0.095	-0.026	-0.086	-.151*			
6. English Skills	4.382	0.329	0.052	0.085	0.078	-0.004	-0.046		
7. Relationship conflict	1.683	0.636	-0.037	0.127	-0.091	-.143*	-.404**	0.011	
8. Task conflict	1.758	0.569	0.006	0.124	-0.049	-0.039	-.340**	0.004	.805**

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

To assess our hypotheses, as mentioned, we resorted to additive moderation analysis (Hayes, 2017). We analysed the effects of the moderating effects of both English skills and openness to linguistic diversity on the relation between diversity and conflicts.

Table 3 shows the results which failed to support a positive relationship between national diversity and task conflict (b = -.12, p>.05) and relationship conflict (b = -1.08, p>.05). Therefore, our hypotheses 1a and 1b were not supported. Hypotheses 2 and 3 predicted moderating effects of English skills and openness to linguistic diversity, respectively, on the positive relationship between national diversity and the two types of conflict. Our results only supported hypothesis 3a (b =-2.87, p<0.01) and hypothesis 3b (b = -2.93, p < 0.001).

We then followed up with slope tests to probe the strength and direction of these interaction effects. The results from the slope test for hypothesis 3 showed that. for teams with a low level of openness to diversity, the effect of national diversity on both types of conflict is positive and strong (for task conflict, b = 2.09, p<.05; for relationship conflict, b = 1.02, p>0.05). Such positive effects became weaker for teams with an average level of openness to linguistic

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diversity and even turned negative for teams with a high level of openness to linguistic diversity (for task conflict, b = -.53, p>.05; for relationship conflict, b = -1.66, p<0.001).

Table 3. Additive Moderation Results

Variable	DV = Task Conflict				DV = Relationship Conflict			
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*	*Model 7*	*Model 8*
Controls								
Team Size	-0.00 (0.78)	-0.01 (0.06)	0.07 (0.06)	0.07 (0.06)	-0.05 (0.06)	-0.06 (0.06)	0.01 (0.07)	0.01 (0.07)
Male Percentage	0.274 (0.15)	0.26 (0.15)	0.24 (0.14)	0.22 (0.14)	0.28 (0.16)	0.26 (0.17)	0.23 (0.14)	0.20 (0.25)
Readiness Score	-0.001 (0.01)	-0.00 (0.01)	0.00 (0.01)	-0.00 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Step 1: National Diversity								
National diversity (ND)	-0.12 (0.56)	-0.18 (0.57)	0.78 (0.67)	0.63 (0.67)	-1.08 (0.62)	-1.19 (0.63)	-0.32 (0.71)	-0.34 (0.71)
Step 2: Moderators								
English Skills		0.83 (1.17)	--	-0.02 (0.11)		0.01 (0.13)	--	-0.03 (0.11)
Openness to Linguistic Diversity		--	-0.47*** (0.08)	-0.40* (0.08)		--	-0.64*** (0.08)	-0.65*** (0.08)
Step 3: Multiple Additive Moderation								
ND * English Skills		-0.98 (1.34)	--	-1.70 (1.24)		-1.85 (1.48)	--	-2.65* (1.31)
ND * Openness to Linguistic Diversity		--	-2.87*** (0.92)	-3.07* (0.93)		--	-2.93*** (0.97)	-3.24 ***(0.98)
R2	0.02	0.02	0.17	0.18	0.38	0.04	0.26	0.27
F	1.04	0.78	8.15***	6.35***	2.31	1.80	13.42***	10.67***

* p ≤ 0.05 *** p ≤ 0.001

According to Hypothesis 4, both English skills and openness to linguistic diversity additively moderate the effect of national diversity on the two types of conflict. Results show that for task conflict, the interaction between national diversity and English skills was non-significant (b = -1.70. p>.05), but the interaction between national diversity and openness to linguistic diversity is significant (b = -3.07, p<.001); thus the effect of national diversity on task conflict was additively impacted by the two moderators [$R^2\Delta$ = .04, F(2, 229) = 5.81, p<0.01](Table 2). On the other hand, when relationship conflict was the dependent variable, both interaction terms were found significant and addictively moderated the relation between national diversity and relationship conflict [$R^2\Delta$ = .04, F(2, 229) = 6.62, p<0.001].

Then, as shown in Table 4 and Figure 2, the slope test showed that, the effects of national diversity are the strongest and positive on both task conflict when the two moderators are low (b = 2.13, p<0.05) and relationship conflict (b = 2.02, p<0.10). However, the effects turn negative on task conflict (b = -1.46, p<.05) and relationship conflict (b = -2.70, p<0.001) when both are high.

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Table 4. Conditional effects of the focal predictor at values of the moderator(s)

		Effect of National Diversity on					
		Task Conflict			Relationship Conflict		
English Skills	Openness to Linguistic Diversity	*b*	*se*	*t*	*b*	*se*	*t*
Low	*Low*	2.13	0.98	2.18*	2.02	1.16	1.73 †
Low	*High*	-0.15	0.61	-0.26	-0.95	0.65	-1.46
High	*Low*	0.83	0.9	0.93	-1.22	0.84	-1.45
High	*High*	-1.46	0.65	-2.23*	-2.70	0.75	-3.59***

* p ≤ 0.05 *** p ≤ 0.001

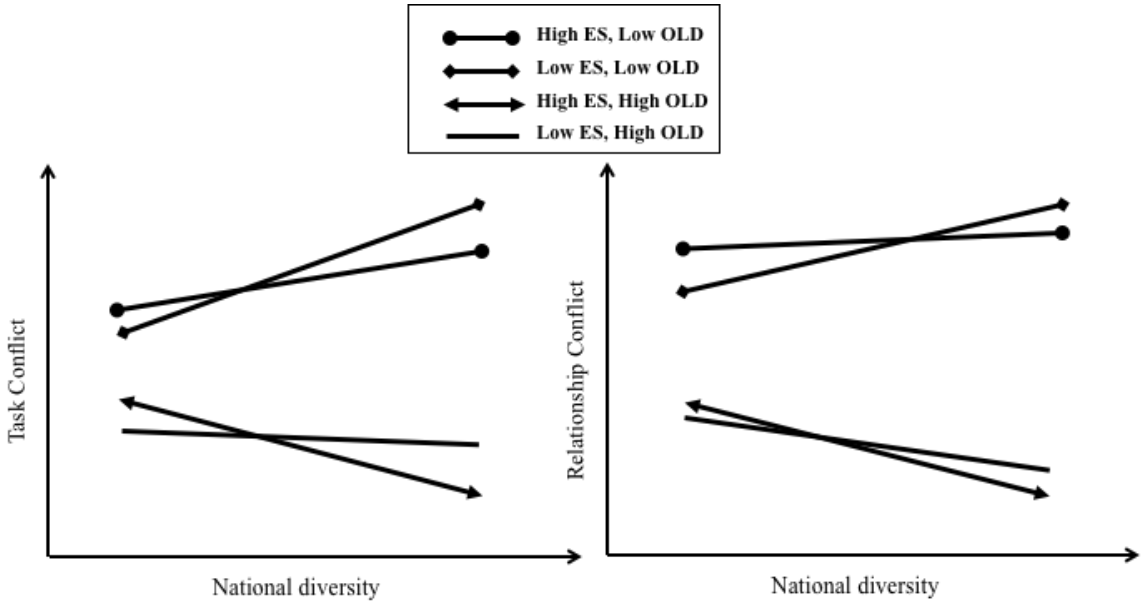

Figure 2. Interaction plots

Conclusion

This study attempted to unravel the effect of national diversity on task and relationship conflict. Data from 283 GVTs show that national diversity does not have a direct significant effect on conflict. A closer inspection of this relationship, however, shows that English skills and openness to linguistic diversity do play a moderating role. Specifically, when both team English skills and openness to linguistic diversity are high in GVTs, the relationship between national diversity and both types of conflict is negative, i.e., teams with this high/high characteristic experience less conflict as diversity increases. When team English skills and openness to linguistic diversity in the team are both low, the opposite is observed. Here, task conflict increases as national diversity on the team increases. High team English skills amplify the negative relationship between team national diversity and conflict when openness to linguistic diversity is high, and low team English skills amplify the positive relationship between team national diversity and conflict when openness to linguistic diversity is low.

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These results help to disentangle the effects of national diversity in GVTs' outcomes by considering the moderating impact of communication-related factors. Our findings amplify and confirm the findings of previous studies, which indicate diversity can have both positive and negative effects in teams (Ayub & Jehn, 2011). Our results suggest that, with regard to team conflict, communication-related factors are key. Minbaeva, Fitzsimmons & Brewster (2021, p. 50) point out that in order to advance our understanding of the mechanisms of diversity it is necessary to move beyond "cultural diversity per se to how the diversity is managed". In discussing this issue, the authors stress the importance of inclusion as a way to reap the benefits of diversity as a strategic resource.

Implications for practice

Our findings can help practitioners identify conditions under which diversity is an asset for GVTs and situations in which it is a liability. In particular, the importance of openness to linguistic diversity, an attitudinal variable which weakens the positive impact of diversity in conflict and even turns it negative for teams with a high level of openness to linguistic diversity, has far-reaching implications for training and human resources management strategies. Diversity training focused on attitudes toward language diversity could be a very effective tool for helping to reduce conflict in GVTs. Team members who are exposed to diversity training are likely to gain a better appreciation for differences among team members and avoid in-group/out-group divisions. Emphasizing the point that differences in language skills in the team's common language are not an indication of a lack of general intelligence could help team members to better appreciate the contributions of fellow team members, even if they are eloquently stated. A greater appreciation and respect for diversity in the team would hopefully also result in team members exhibiting more patience in their interactions with those who struggle in the common language. An increased level of patience, along with more frequent use of techniques such as restating, summarizing, and clarifying would likely lead to less conflict, better communication, and improved team performance. Therefore, we strongly suggest that managers put more emphasis on providing training for employees assigned to work in GVTs which concentrates on improving team-members' openness to linguistic diversity. While helping team members increase their skills in the GVT's common language can also help, further emphasis on attitudinal variables such as openness to linguistic diversity may be even more impactful.

Directions for future research

In an increasingly global world, GVTs will continue to play an important role in international collaboration in different business and non-business contexts.

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In order to improve their effectiveness, a better understanding of the perceptions and experiences of groups' dynamics is required. Future research addressing the communication aspects that facilitate GVTs group dynamics and interpersonal relationships remains a fertile area for study. In particular, researching potential mediators and moderators in the diversity-conflict relationship, especially attitudinal variables, continues to be important, as previous research has emphasised that the impact of diversity in team performance is indirect (Stahl & Maznevski, 2021). It is also important to understand how and when national diversity has positive implications: are there minimum levels of diversity below or above which the negative/positive effects of diversity become salient? A Necessary Condition Analysis approach may allow for the identification of the 'must-have and should-have factors' for benefiting team diversity (Richter *et al.*, 2020). Ayub & Jehn (2018), for example, found that the impact of national diversity depended on the number and specific mix of nationalities present (with higher or lower perceived social distance). Additional work along these lines would add further nuance to our understanding of the links between diversity and performance in GVTs.

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Enhancing Decision-Making Consistency in Business Process using a Rule-Based Approach

Case of Business Intelligence Process

Riadh Ghlala
Higher Institute of Technological Studies of Rades, Tunisia
University of Tunis, ISG Tunis, SMART Lab, Tunisia

Zahra Kodia
University of Tunis, ISG Tunis, SMART Lab, Tunisia

Lamjed Ben Said
University of Tunis, ISG Tunis, SMART Lab, Tunisia

Abstract: Decision-making in Business Process is a real challenge, given its technical complexity and organizational impact. Mostly, decision-making is based on business rules fired by an inference engine using facts reflecting the context of the current process task. Focus on a task alone and in isolation from the rest of the process can easily lead to inconsistency in decision-making. In this paper, we aim to improve the importance of consistency of decision-making throughout the process.

To fulfill this aim, our contribution is to propose Consistency Working Memory RETE (CWM-RETE): a Framework based on the Rete Algorithm as a pattern-matching algorithm to simulate inference; and MongoDB as a document-oriented database to serialize business rules. This framework enables the compatibility of decision-making throughout the business process. The experimentation is based on the Business Intelligence process as a case study and it is shown that the decision-making process can generate different results depending on whether consistency functionality is enabled or not.

Keywords: Decision-making in Business process, Consistency, Rete Algorithm, MongoDB, Business intelligence

Introduction

The new millennium is marked by the wide-spread use of Business Intelligence (BI) with all its subspecialties, such as data collection, data cleansing, data warehousing, data analysis, data

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analytics, reporting, dashboarding, and score-carding (Cheng & Cao, 2020). Different tasks of a BI process involve various technologies, models, techniques, and approaches. Therefore, the implementation of a BI process must cover all the factors related to the panoply of choices which are constantly multiplying. This is due to the invasion of new technologies such as IoT, Big Data, mobile development, and others. Mastery of decision-making during any process and in particular a BI process aims to ensure alignment between the expectations of managers and the solutions proposed by IT: a key concept of Enterprise Architecture (EA), namely Business-IT Alignment (Dokhanchi & Nazemi, 2015).

The EA models any IT solution using four layers: business, functional, information and infrastructure layers (Winter & Fischer, 2006). Despite its importance, the business layer is usually neglected, leading to a gap between the request and the delivered solution. To overcome this gap, several models have been developed, such as the Business Process Model and Notation (BPMN) (OMG, 2014) and the Decision Model and Notation (DMN) (OMG, 2016). These standards are proposed by the Object Management Group (OMG) to contribute to business process modelling. Success of these two models has favoured the appearance of several Business Process Management Systems (BPMS).

In these BMPS, decision-making is restricted to business rules eligibility. This mission is well ensured by the Rete algorithm (Forgy, 1982). This inference algorithm, also called a pattern matching algorithm, allows the matching between facts forming its working memory and rules forming its production system. The working memory represents the different factors to take into consideration to make a choice in the current task of the process. The production system represents business rules related to the business process to generate, by inference, new facts leading to decision-making.

In addition to business rules eligibility, decision-making consistency is a high demand quality in business processes (Awadid & Nurcan, 2016). In the literature, this feature has been studied in different ways. In the medical sciences, a patient's history is tracked so as not to prescribe drugs that may have undesirable effects with the current situation and previous prescriptions. The optimal decision is therefore to prescribe the right drug that best suits the patient's antecedents (Shariff *et al.*, 2022). By analogy, decision-making in business processes must check the characteristic of consistency to consider, at a given step, all the decisions already made in the previous steps, so as not to try to excel in the current task, even in a contradictory way, with what already exists.

Consistency requires, on the one hand the retention of all decisions taken throughout the process and, on the other hand, the ability to explore this repository to confront the decision in an ongoing task with those already taken.

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Indeed, it is considered in some contexts as a solution to impose ethics; in other contexts, as an approach to foster collaboration; and, in other cases, as a mechanism to achieve standardization.

We define consistency as a solution to ensure compatibility and synchronization of decision-making along the process. Decision-making in a process task must be ensured by covering at the same time factors relating to the task itself and factors resulting from the previous tasks. Thereby, decision-making should not be isolated and localized at the task level, but rather consistent. Consistency must be ensured by dealing with the intrinsic and extrinsic.

In this paper, our contribution is to extend the Rete algorithm to support decision-making consistency in a business process. This extension must be ensured without generating nuisances on the business, functional or technical sides. In a BI process, decision-making consistency is very much required and, if it is ignored, according to experts in the field, it can have a very costly impact on the outcome. That is why we chose this domain to test our model. The choice of BI domain is indicative and not exclusive.

The paper is organized as follows. In the Background and Related Works section , we present previous works on decision-making consistency in business processes. The next section, named Our Proposed Model of Decision-Making Consistency in Business Process using CWM-RETE, is devoted to presenting and validating our CWM-RETE model through a BI process, while emphasizing the importance of consistency of decision-making in this kind of process and the role that the Rete algorithm could play in this case. In the results section , we discuss the results obtained and the impact of this work on decision-making in business processes. The Conclusion section summarizes our findings and suggests future extensions of the current work.

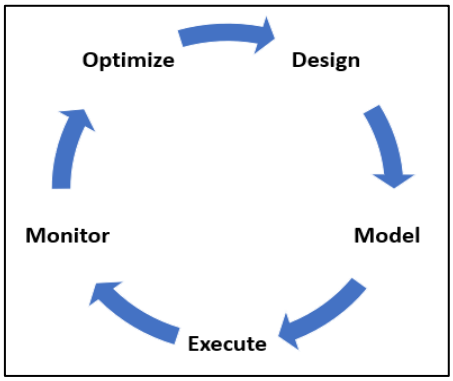

Figure 1. BPM Life Cycle

Background and Related Works

According to Gartner, Business Process Management (BPM) is a discipline that uses various methods to discover, model, analyze, measure, improve, and optimize business processes

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(Gartner, 2017). Figure 1 illustrates the life cycle of a business process with its different phases. Each of them was the topic of several works to improve these business processes. The axes discussed in the literature are numerous, such as integration, distribution, collaboration, standardization, harmonization, and consistency. Improved decision-making is a key focus for improving these business processes.

Decision-making in Business Process

To identify the different works on decision-making in a business process, we can structure this section around three major axes: (1) the separation between business process modelling and decision-making modelling; (2) the various implementation scenarios and integration of business rules; and (3) improvement of inference engine handling these business rules.

Indeed, the first preoccupation was concentrated on the separation between decision-making modelling and process modelling (Batoulis *et al.*, 2015; Biard *et al.*, 2015). Research in this field is based on the collection, modelling and integration of business rules in business processes (Kluza & Nalepa, 2013; Bajwa, Lee & Bordbar, 2011). Overarching this work is the Decision Model and Notation (DMN) (OMG, 2016) which has become a standard in modelling decision-making in business process (Taylor, Fish, & Vincent, 2013). Figure 3 shows an excerpt from a BI process in which we use these standards to model decision-making at the online analytical processing (OLAP) task.

The second focus is the serialization of business rules and automation of their processing and exchange (Ghlala, Kodia Aouina & BenSaid, 2016). A range of choices can be adopted to achieve this mission, such as (1) programming languages (procedural or object-oriented) (Batoulis *et al.*, 2015); (2) exchange data formats (XML or JSON) (Biard *et al.*, 2015); (3) aspect-oriented languages (Taylor, Fish & Vincent, 2013); (4) databases using the relational model (Bajwa, Lee & Bordbar, 2011); (5) rules engines (Kluza & Nalepa, 2013); and (6) business process management systems (Ghlala, Kodia Aouina & BenSaid, 2016). Several open-source and proprietary software systems have appeared and are in competition to implement both BPMN and DMN standards, as well as support for business rules based on BPEL and FEEL languages (Skersys, Tutkute & Butleris, 2012).

The inference of business rules in BPMS represents the third focus. Indeed, the improvement of the inference engine represents a promoter track both on the tuning and the functional aspects. Since the Rete algorithm is the main used algorithm in BPMS (Gartner, 2017), several research works were intended to improve it. On the one side, reflecting the improvement of this algorithm on the performance axis, much research focuses on the indexing of the working memory, such as in Van De Water *et al.* (2015) and others, who propose the improvement of the matching algorithm (Yay, Martínez Madrid & Ortega Ramírez, 2014). On the other side,

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which focuses on the improvement of features of this algorithm, we can quote the distribution of the inference (Wang *et al.*, 2014) .

Consistency in Business Process

Consistency, our topic of interest in this paper, is considered in various systems as an advanced feature. It is defined as the fact that the information covered in each model in Business Process should not contradict one other (Awadid & Nurcan, 2019). It can concern two tracks: (1) consistency of the business process itself (Branco, 2014); (2) consistency of the decision-making in these processes (Argandona, 2008).

In the first track, where the focus is on the process itself, several works have dealt with the syntactic and semantic aspects of this consistency (Humm & Fengel, 2012). Other works are oriented towards the ethical dimension of consistency (Schweitzer & Gibson, 2008). Indeed, in many systems, such as banking systems (Branco *et al.*, 2014), healthcare systems (Finch, Geddes & Larin, 2005) or the judiciary system (Finlay & Ogden, 2012), consistency is considered as having the same behaviour in similar contexts. In the second track, consistency is related to the decision-making in business processes; some studies insist on cognitive consistency in collective decision-making, also called group decision-making (Mojzisch *et al.*, 2014).

In the literature, there are two approaches to ensure consistency: a rule-based approach which consists of ensuring consistency across business rules (Goedertier & Vanthienen, 2005) and a constraint-based approach that relies on programming by constraints (Runte, 2012).

Using a constraint-based approach, Piotr, Krzysztof & Antoni (2018) propose a user-friendly method of business process composition. They generate a set of constraints based on a log of the process, which details activities to be performed. The consistency in this work is considered as an intra-activity unification. Another research work in Mafazi (2015) uses a semantic-based approach for verifying consistency and correctness of process models. The authors propose a novel process abstractions' configuration with respect to a specific goal expressed as constraints. Their constraint-based framework shows that consistency can be used to improve conformity.

Using a rule-based approach, Torre *et al.* (2018) provide a set of UML consistency rules in UML Standard. This work emphasizes verifying and checking the models.

The concept of consistency is sometimes crossed with harmonization and standardization concepts. According to Romero *et al.* (2012), harmonization is considered as the degree of similarity between different business processes and the degree of adaptation of these business processes to their environment. In addition, Ross, Weill & Robertson (2006) proposed an

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operating model allowing the classification of processes into four categories (diversification, replication, coordination and unification) according to their degree of standardization, whereas Wüllenweber *et al.* (2009) define the objective of process standardization as making process activities transparent and achieving uniformity of process activities across the value chain and across firm boundaries. Harmonization and standardization are aimed at setting up procedures for bringing various business processes together based on standards or analogies. Recently, new concepts are emerging in the context of digital transformation. Baiyere, Salmela & Tapanainen (2020) propose to rethink the BPM logic and dissociate its dynamics. They identify three components: (1) light touch processes; (2) infrastructural flexibility; and (3) mindful actors.

Our observations contribute to a rethinking of the dominant BPM logic by unpacking its dynamics in the context of digital transformation. In this paper, our contribution is the improving of decision-making in business intelligence process by emphasizing consistency through rules-based approach. Our concern is to ensure compatibility between the different decisions made throughout the process.

Our Proposed Model of Decision-Making Consistency in Business Process using CWM-RETE

Decision-making consistency in business processes consists in making a choice in a task of the process while considering all factors related to the task itself, named the intrinsic factors, and legacy factors relating to previous tasks, named the extrinsic factors. The BI process can serve as a very representative case study to discuss this need.

The use case of BI process

BI development has encouraged companies to invest in this kind of project to implement IT solutions to help managers make the best decisions at the right time. These projects can be described as a data-driven Decision Support System (DSS) that combines data gathering, data storage and knowledge management with analysis to provide input to the decision process (Negash & Gray, 2008).

Nowadays, we note at least three types of BI projects: (1) Corporate BI Projects (Ghlala, Kodia Aouina & BenSaid, 2016; Mitrovic, 2020); (2) Data Visualization Projects (Lea, Yu & Min, 2018; Mei *et al.*, 2020); and (3) BI Projects in the era of big data (Saggi & Jain, 2018; Alnoukari, 2022). In this paper, we focus on the corporate BI process depicted in Figure 2.

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Considering the different kind of BI projects and the diversity of decision makers 'profiles, in modelling processes, remains very complex. This complexity is due to several factors such as: (1) the different requirements of the managers; (2) the range of technologies in the market; and (3) the context of design, development, and deployment of the process (sequencing, parallelism, centralization, and distribution of tasks). In addition to these different constraints, through modelling decision making process, we must ensure coherence and harmonization in the overall project tasks, and enhance the consistency of decisions throughout the process.

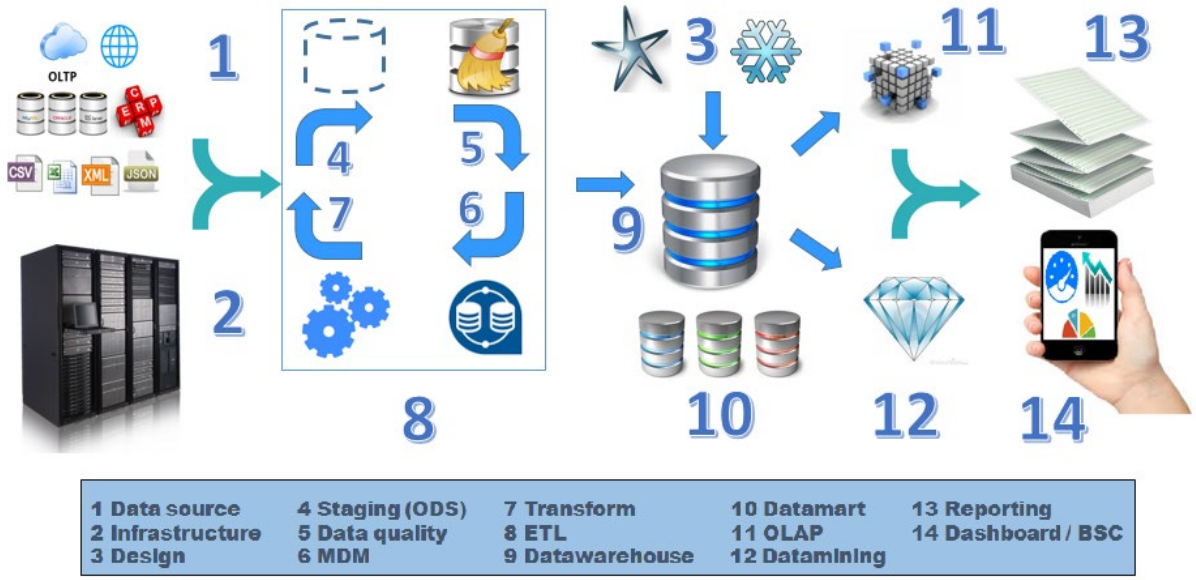

Figure 2. BI Process

3.2. Intrinsic and extrinsic factors

As shown in Figure 2, the BI process is composed of several tasks, each requiring decision-making that we want to be done with consistency. Among these tasks, we study the OLAP task that specifies the various choices relating to multidimensional cubes as a storage and refresh strategy. Figure 3 shows the design of this task with the OMG BPMN and DMN models. The graphical representation of the decision-making is well ensured by the DMN, while the eligibility of the various business rules is entrusted to the Rete algorithm. The latter is a very efficient algorithm which matches facts against the patterns in rules (Van De Water *et al.*, 2015). Also, knowing that the Rete algorithm is the most used as the inference engine in BPMS like Drools, Bonita Soft BPM, Oracle BPM and Red hat JBOSS BPM Suite (Gartner, 2017), we choose to extend this algorithm by the consistency feature.

The factors that directly affect the decision in a task are identified by intrinsic factors. These factors play a crucial role in decision-making at the task level but are not sufficient. In fact, the current task can be biased by some intrinsic factors of the previous tasks, which we consider

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as extrinsic factors. Thus, when deciding, we must consider at both these intrinsic factors and the extrinsic factors for our current task.

Consistency in a BI process is ensured by defining a set of business rules. These rules are formulated based on intrinsic and extrinsic factors relating to each task in process. In Table 1 and Table 2, we present, respectively, the intrinsic and the extrinsic factors identified for the OLAP task in BI process.

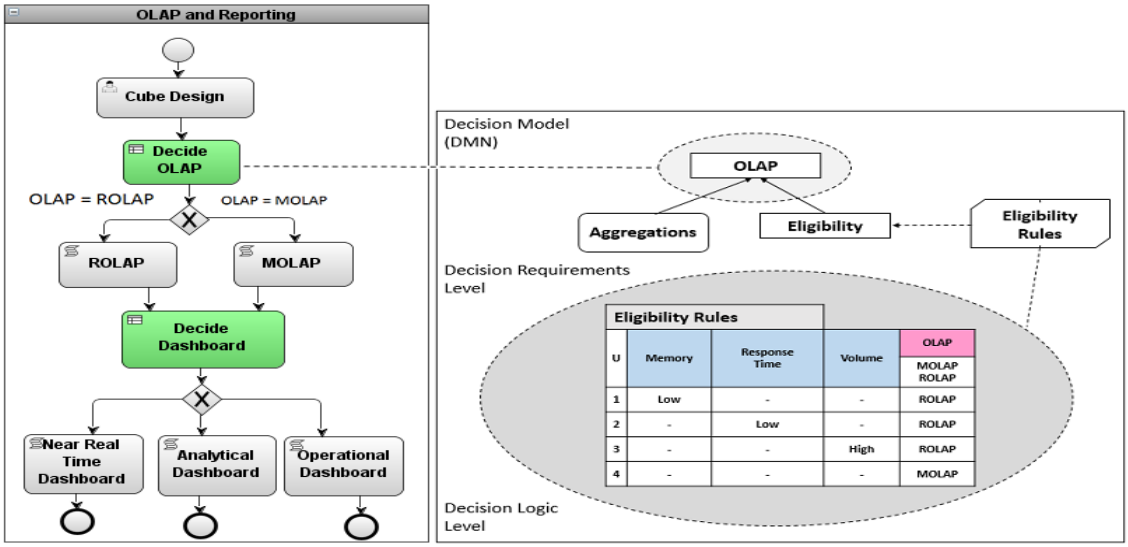

Figure 3. BPMN and DMN Design of OLAP and Reporting Task

Table 1. Intrinsic factors of OLAP decision related to OLAP and Reporting task

Factor Designation	Factor Description	Factor Nature
Memory size	Available memory size	Quantitative
Cube size	Cube size in gigabyte	Quantitative
Refresh	Need to access updated data	Qualitative
Response Time	Need fast access to the data	Qualitative

Table 2. Extrinsic factors of OLAP decision related to OLAP and Reporting task

Factor Category	Factor subcategory	Value	Description
Extraction	Mode	Periodic	Periodic extraction
		Continuous	Continuous extraction
	Direction	Pull	Refresh managed by the BI system
		Push	Refresh managed by the OLTP system
	Staging	Yes	Staging
		No	No staging
	Transform	Fast	Fast and minimal transformation
		Slow	Slow and multiple transformation
Design	Model	Star	Star schema
		Snowflake	Snowflake schema
	Datawarehouse Architecture	Independent DM	Independent datamarts
		DM bus	Datamarts bus
		Hub-and-spoke	Hub and Spoke topology

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Factor Category	Factor subcategory	Value	Description
		Centralized	Centralized datawarehouse
		Federated	Federated datawarehouse
	Fact tables	Transaction	Exhaustive measures in the fact table
		Snapshot	Historical measures in the fact table
		Accumulated	Cumulative measures in the fact table

Our Contribution: Consistency Working Memory Rete Framework

Every decision made in a business process task must be remembered for future tasks. Memorization involves three main elements: the choice made; the factors that favoured this choice; and the choices to be avoided in the following tasks. The role of domain experts in setting up this strategy is essential, regarding the holistic nature of the skills needed for successful implementation of this approach.

Figure 4 shows the architecture of our model. It is composed of four parts:

1. ***Production memory***: repository containing business rules related to the business process.
2. ***Working memory***: instance of the memory containing the various facts introduced by the user through the graphical interface representing the intrinsic factors with, in addition, the facts generated by inference and, possibly, the extrinsic factors as facts injected following the access to the repository to ensure consistency.
3. ***Agenda evaluation***: instance of the memory where eligible rules to be executed are stored.
4. ***Legacy decision repository***: repository containing the different decisions taken throughout the process. The memorization of these latter items is encoded in JSON format to bring more flexibility, performance, and adaptation with the document-oriented databases.

The first three components ensure functionalities of the regular Rete algorithm components. The fourth one is our contribution as a repository containing the legacy decisions to ensure consistency.

A stored decision in working memory is characterized by different information describing the context of its adoption, namely:

- The chosen value;
- The factor(s) favouring this decision;
- A blacklist containing the choices to be avoided later in the process.

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The considered characteristics of the stored decisions are heterogenous and multivalued. The origins of this variety are due to two anomalies concerning multivalued and missing data. Consequently, several formalisms are candidates to play the role of the representation of these stored decisions. Among these formalisms, we consider SQL, XML and JSON.

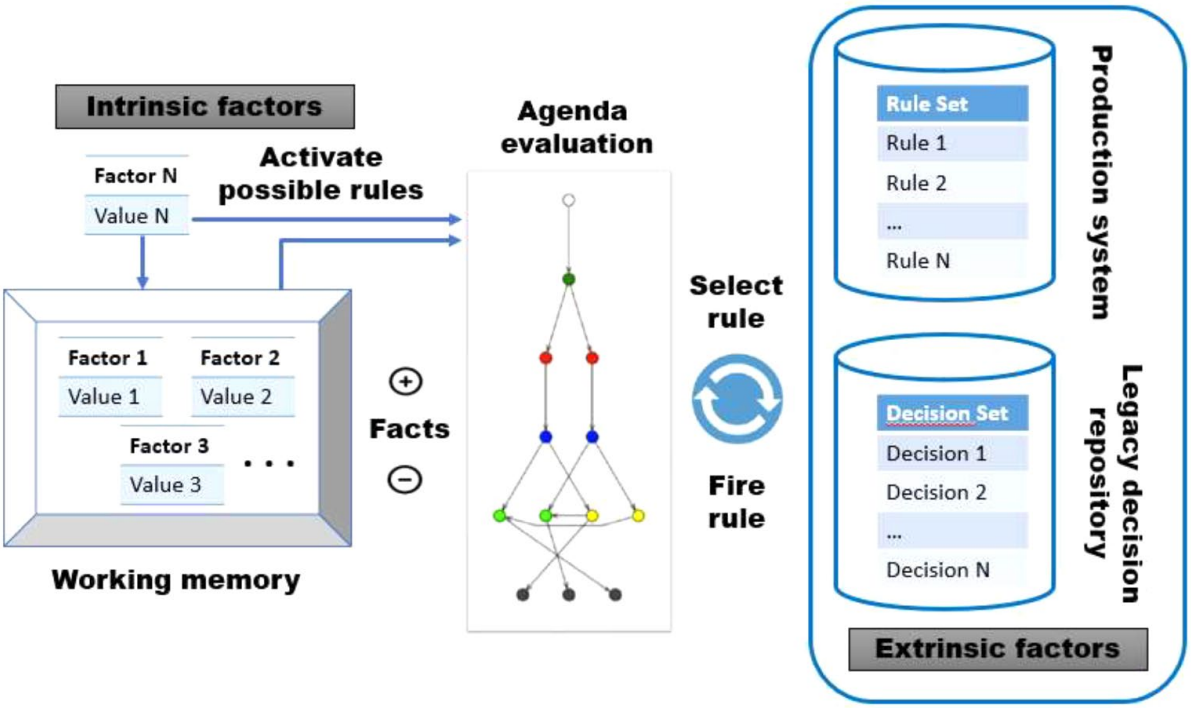

Figure 4: Consistency Working Memory (CWM) RETE Framework

Experiments and Results Interpretation

The experimental study of CWM-RETE relies on MongoDB as a decision serialization tool and Pyknow as a Python library to simulate the running of our model using the CWM-RETE algorithm. The dataset is the result of collecting and analysing business rules from groups of experts on BI in real companies.

The choice of MongoDB as a NoSQL database of the document-oriented category is explained by its flexibility of business rule modelling. This type of database is designed to store, retrieve, and manage semi-structured data. They are suitable for projects requiring data with a schema-less implementation. Indeed, in the same collection, documents can have different structures in terms of number, size, and content of their fields. Another handy feature of MongoDB is the ability to model multi-valued data. This feature simplifies the modelling of relationships such as (1: 1), (1: N) and (N: M) between different real-world entities. On the other side, the choice of Python is explained by its ability to innovate in several scientific fields. Indeed, it is a pluggable environment with a lot of libraries to cover several issues. In our case, we opted for the Pyknow library to simulate the execution of the Rete algorithm.

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CWM-RETE implementation

To test our model, we implemented a framework with the following features:

- Creation of a MongoDB database containing the previous decisions. This repository contains extrinsic factors for the current task. Each decision is identified by an *Id*, relating to a task of the process, characterized by the list of *Factors* that leads to the chosen choice, and a *Blacklist*. The latter represents the choices to be avoided in the rest of the process, given the choice adopted in the chosen task. Figure 5 shows an example of a decision stored in this repository used by our framework to ensure consistency.

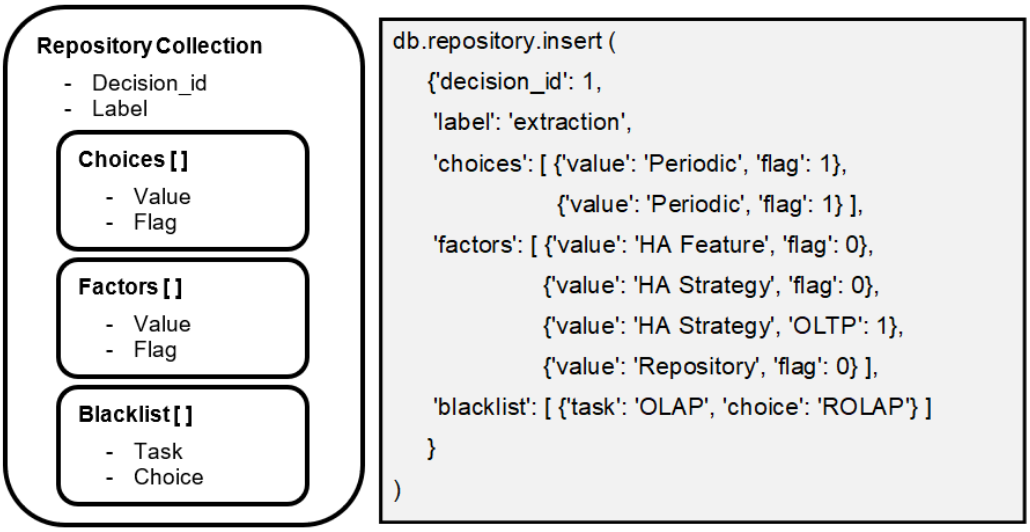

Figure 5. Legacy decision design and serialization

```
# Rules on Response time #
  @Rule(CWM_OLAP(response_time="High"))
  def RS1(self):
    self.declare(CWM_OLAP(OLAP="MOLAP"))

@Rule(CWM_OLAP(response_time="Midium"))
  def RS2(self):
    self.declare(CWM_OLAP(OLAP="HOLAP"))

  @Rule(CWM_OLAP(response_time="Low"))
  def RS3(self):
    self.declare(CWM_OLAP(OLAP="ROLAP"))

# Rules on Data Refresh #
  @Rule(CWM_OLAP(refresh='Yes'))
  def RS4(self):
    self.declare(CWM_OLAP(OLAP="ROLAP"))
    print("Rule RS3 Fired")

  @Rule(CWM_OLAP(refresh='No'))
  def RS5(self):
    self.declare(CWM_OLAP(OLAP="MOLAP"))
    print("Rule RS3 Fired")
```

Figure 6. Excerpt from the production memory

We use the Pyknow library to formulate business rules for the OLAP task. Each business rule of the production system is a static Python method. Business rules resulting from access to the repository are implemented as dynamic methods. Figure 6 shows an excerpt from the production memory.

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We have developed a GUI (Graphical User Interface) to interact with the software to introduce the facts and scenarios of execution (access or not to the repository, to activate or not to activate the consistency feature).

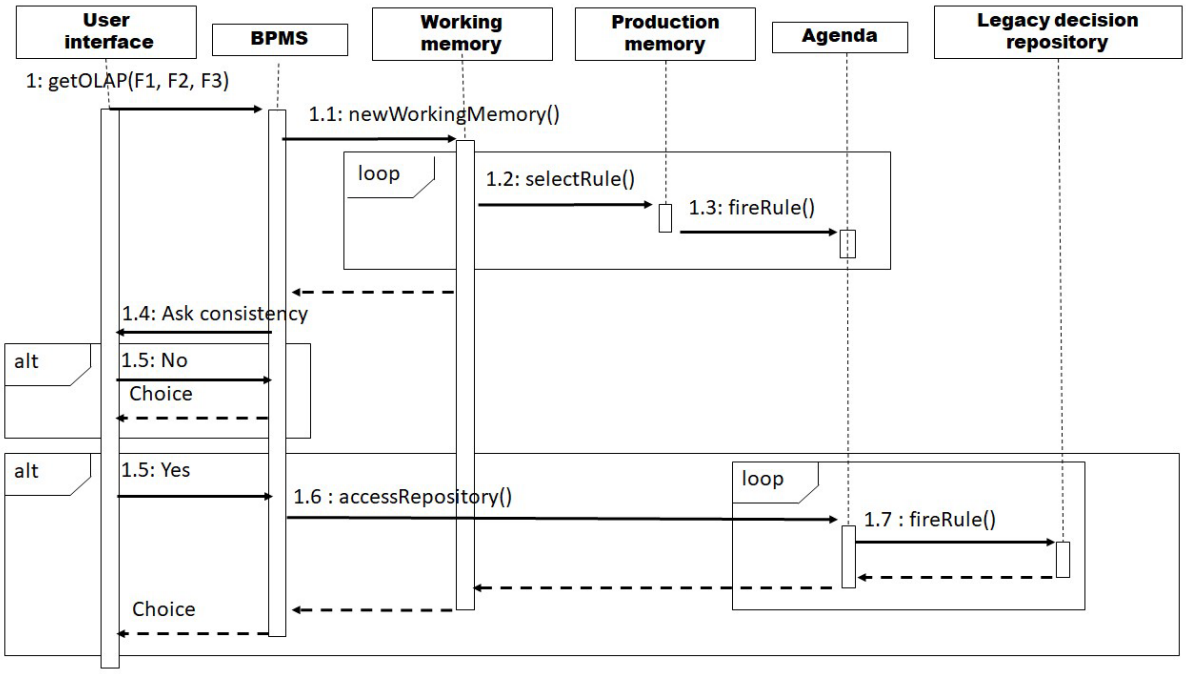

Figure 7. Sequence diagram relating to the execution of CWM-RETE

The extension of the Rete algorithm is provided by the implemented framework. The latter performs as showed in the sequence diagram, which details the CWM-RETE algorithm. As shown in Figure 7, our algorithm can be summarized as follows:

1. After collecting factors F1, F2 and F3 through the user interface, the BPMS generates a new working memory.
2. The working memory selects the activation rule and loads it into the production memory, which interacts with the agenda.
3. If the consistency functionality is enabled, an access to the repository is performed with the current task label as a keyword to search for the different decisions stored in this repository that relate to the current task.
4. The decisions are transformed into business rules and dynamically integrated into the production system of the algorithm.
5. The algorithm is re-run using the new production system.

Since the functionality of the consistency is enabled, the CWM-RETE algorithm has accessed the repository to identify the stored decisions in relation to our current OLAP task and generate extrinsic factors to load them into the working memory. The OLAP_Task class (Figure 8) contains the business rules for the OLAP task that are developed by the PyKnow library.

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```
class OLAP_Task(KnowledgeEngine):
    # Rules on cube storage
    @Rule(CWM_RETE(response_time = "High"))
    def R1(self):
        self.declare(CWM_RETE(OLAP="MOLAP"))
    @Rule(CWM_RETE(response_time = "Midium"))
    def R2(self):
        self.declare(CWM_RETE(OLAP="HOLAP"))
    @Rule(CWM_RETE(response_time = "Low"))
    def R3(self):
        self.declare(CWM_RETE(OLAP="ROLAP"))
    # Rules on response time using comapre function
    @Rule(CWM_RETE(compare(memory,cube_size)=1))
    def R4(self):
        self.declare(CWM_RETE(OLAP="ROLAP"))
    @Rule(CWM_RETE(compare(memory,cube_size)=2))
    def R5(self):
        self.declare(CWM_RETE(OLAP="HOLAP"))
    @Rule(CWM_OLAP(compare(memory,cube_size)=3))
    def R6(self):
        self.declare(CWM_RETE(OLAP="MOLAP"))
    # Rules on data refresh
    @Rule(CWM_RETE(refresh = "Yes"))
    def R7(self):
        self.declare(CWM_RETE(OLAP="ROLAP"))
    @Rule(CWM_RETE(refresh = "No"))
    def R8(self):
        self.declare(CWM_RETE(OLAP="MOLAP"))
```

Figure 8. Extrinsic factors generation using CWM-RETE

Results and discussion

To integrate consistency into decision-making in business processes, our work is summarized in the elaboration of a framework for testing our new model, CWM-RETE. With this framework, decision-making in a business process is not necessarily done based on intrinsic factors only, but can be expanded to also cover the extrinsic factors already stored in a repository. Our work contributes to improving business processes by adding consistency in decision-making as a new feature to remedy the lack of this need detected in the state of the art. The study led to the following observations.

The experimental study showed that decision-making in the same task, in our case based on that of OLAP, provided different results depending on whether the consistency feature was activated.

The impact of choosing either MOLAP or ROLAP in a BI process is very crucial. Indeed, the MOLAP choice requires a high memory capacity to host data cubes in order to accelerate access to measures and dimensions. This acceleration comes at the expense of analysis freshness, since the MOLAP cubes do not access the data warehouse in real time, but, rather, they do a periodic refresh.

In the other case, the ROLAP choice does not require a large memory capacity but it requires real-time access to the data warehouse to ensure the freshness of analysis. The two strategies

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are totally divergent and the choice of one or the other does not depend only on the intrinsic factors relating to the OLAP decision, but it also depends on previously taken decisions, especially the type of the Extract, Transform and Load (ETL) process used to load data in the data warehouse from the data sources.

ROLAP can be a suitable choice if the type of ETL chosen previously was a continuous data extraction from source to data warehouse, whereas MLOAP would be an appropriate choice if the type of ETL was periodic.

These observations and results suggest that consistency in the decision-making process should be considered for many reasons.

Firstly, the simulation of the CWM-RETE model has shown that decision-making can lead to different results depending on whether consistency functionality is enabled. Indeed, in the OLAP task of a BI process, we can opt for a choice of MOLAP if we only use the intrinsic factors. However, we may be faced with a choice of ROLAP if we activate the consistency functionality.

Secondly, consistency must check at least the following characteristics:

- Flexibility: this characteristic allows the user to enable or disable this feature based on the task nature and the level of consistency required.
- Integration: the implementation of this feature must be ensured without additional technical or functional requirements.

Thirdly, new challenges have emerged to best cover this consistency feature, namely:

- Distribution: The implementation of this feature is further complicated in a distributed context. In this case, both decision-making consistency and consensus between users are required. This coupling leads to group decisions with consistency.
- Performance: This characteristic is the concern of all scalable systems. The explosion of the size of both working memory and production memory necessarily causes tuning issues.
- Genericity: The consistency feature should not be limited to a particular area. The BI process is chosen as a case study, but consistency can be generalized to any kind of process. The challenge is how to simplify the digitization of human expertise in these different areas.

Conclusion and Future Work

Consistency is a needed feature in business processes. It concerns both the process itself in its functional aspects and the decision-making within this process. This functionality is treated

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in different dimensions (ethics, collaborative, and coherence) and there are some implementation proposals based on two approaches (rule-based and constraint-based).

In this paper, we have discussed consistency as a feature enabling the compatibility of decision-making throughout the business process. To argue our idea, we proposed a novel model with a rule-based approach based on the Rete algorithm. The experimental study is ensured through a framework using Python's Pyknow library and MongoDB. This framework simulates consistency in a BI process and more precisely in its OLAP task.

The major conclusion to be emphasized in this work is the absolute necessity to consider consistency in decision-making in business processes whatever the area covered, the intended dimension and the applied approach. As future work, we plan to extend the introduced framework using a constraint-based approach and use this to further examine the agility of business processes and decision models.

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A Secure Attendance System using Raspberry Pi Face Recognition

Rhouma Bin Hamed
College of Applied Sciences (CAS), UTAS, Salalah, Sultanate of Oman

Tarek Fatnassi
College of Applied Sciences (CAS), UTAS, Salalah, Sultanate of Oman

Abstract: This study aims to develop a machine-learning-based attendance management system using face recognition and Raspberry Pi. The proposed system is composed of two main subsystems. The first is a Raspberry Pi, to be installed in each class, and the second is a web application fed by data from the Raspberry Pi. To take attendance, an instructor commands a Raspberry Pi camera through a web-based subsystem. Then, the camera takes a picture of the whole class and detects faces using trained Haar Cascades. It sends back a file with the class picture and Cartesian coordinates of the detected faces. The web application parses the file, looking for the coordinates of faces. For each Region of Interest, it uses the Support Vector Machine algorithm to recognize faces based on their HOG (Histogram of Oriented Gradients) features. The recognizer uses a pre-built dataset of that particular class containing the students' personal photos, names and ID numbers. Features of each face were extracted using HOG and trained to construct the model over a given class of students. Once every detected face is recognized, the application generates a report for the instructor showing the list of students' names and attendance status.

Keywords: Machine learning, SVM, Histogram of Oriented Gradients (HOG), Haar Cascade, Raspberry Pi

Introduction

In this digital era that relies on the use of artificial intelligence (AI), setting up a fully automatic system in a university that allows the recording and management of students' attendance based on face recognition has become an urgent need. Indeed, the attendance system that is currently used by our university is semi-automatic and has many limitations, especially in terms of the time and energy teachers spend on entering attendance. The majority of access control and attendance management systems that exist in the present time are based on

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various technologies, such as fingerprint, RFID (Radio-Frequency IDentification), and Iris recognition. These systems also have time-consuming issues, as they are queue-based and of an intrusive nature.

In contrast to these systems, having an attendance system based on face recognition is more effective as it has been successfully used in several contactless and non-invasive processes. Nowadays, artificial intelligence plays a significant role in all areas, as it helps in improving efficiencies and augmenting human capabilities. In the educational area, for example, AI techniques have been applied to manage the attendance of students in an easy and fast manner (Kamalahasan *et al.*, 2020). Every organization requires a strong and stable system to record class attendance, but they still mainly use a manual system that consists of using hard copies of student lists and asking students to sign next to their names during each class. Other organizations, such as UTAS, are using semi-automatic systems which have many limitations, especially in terms of time and energy. In addition, many organizations have adopted access control and attendance management systems that are fully automatic and use biometric characteristics for the identification of individuals, such as fingerprint, RFID, and iris. These systems are time-consuming, because they are queue-based and of an intrusive nature. However, the use of face recognition methods in attendance systems is considered efficient and smart. In fact, face recognition is faster and more accurate than other techniques, and it is efficient as it reduces the amount of effort a teacher can make while taking attendance (Thaware, 2018; Smitha, Hegde & Afshin, 2020) this paper we propose a smart attendance system that uses sophisticated methods to reduce the cost and reduce the error rate during the record of attendance. This system uses a Raspberry Pi camera to capture and recognize the students' faces. This automatic attendance system is cost-effective, easy and fast, and reduces the amount of effort teachers used to waste while dealing with manual systems. Besides, time and health safety in the present times of COVID-19 constitute a priority for this new system. Class attendance can be taken in a safer and more time-efficient way than the iris and fingerprint methods that are currently applied.

Literature Review

Having an automatic attendance management system became a necessity for educational institutions. Marking attendance manually is very difficult and error prone. Many researchers who are interested in this field tried to give relevant solutions to this problem. Most of the popular methods for attendance management include face recognition (Amritha & Sudhakar, 2019; Qian *et al.*, 2020; Evanjalin *et al.*, 2021; Kowsalya *et al.*, 2019).

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In Qian *et al.* (2020), they proposed an image decomposition scheme to explore the intrinsic structure from different gradient orientations and extend the matrix regression-based classifier for solving the robust face recognition problem. They provided a nice analysis of different image decomposition schemes and have shown that their algorithm succeeds in parsing the complex structure of the image in order to handle facial images with real disguises and illumination changes. However, their method costs more computation time when handling large-scale datasets, since they should compute the nuclear norm minimization problem by using the singular value shrinkage operator iteratively.

In Evanjalin *et al.* (2021), an automatic attendance system based on OpenCV and Raspberry Pi is proposed. The Raspberry Pi camera is used to take video of staff from many angles and under different illuminations. Still images are extracted from the registered videos. Then, Haar-cascades were used for face detection. A Deep Neural Network (DNN) was used to train the staff faces and store them in a mySQL database. This system requires too many computations and raises too many questions: from taking videos, when and what exactly the Raspberry Pi camera is ordered to take videos; how the trimming is done to extract face images; are Haar-cascades turned on videos or on extracted frames from the video. The use of the DNN is also not clearly explained for which features exactly the model is trained on: what features from the faces is the DNN working on? Their system also shows the output timing of a staff recognition. In that case, does the model detect when a staff member is exiting a door? If it does not recognise the existence of a staff member in a room, does it declare the staff member absent? There are too many issues that are not explained in that paper.

Automated Attendance Management Systems based on Face Recognition are used in classes to automatically detect faces of any students while entering the classroom, recognize them, then edit the database by marking them present. Face recognition requires samples to be collected, identified, extracted with necessary information, and stored for recognition. Face Detection is the basis in any operation performed in the face recognition process. The Haar Feature-based Cascade Classifier is a widely used mechanism for detecting faces. In order to train a classifier to detect faces, two large sets of images are formed, with one set containing images with faces, and the other set without. These images are then used to generate classifier models. The classifier is generated by extracting Haar features from the images. The detector and Haar-cascade extracts features quickly and it is easy to use. In our proposed attendance system, we use Haar cascades only in the detection stage. Then, we pass the detected faces to the SVM classifier to analyse the detected faces and label them with the right names/IDs.

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Histogram of Oriented Gradients

HOG is a feature extraction technique that is used in computer vision and image processing (Dalal & Triggs, 2005). It is essentially based on HOG descriptors, which are used also for quantifying and representing both shape and texture. This technique is described according to the distribution of the edge trends in the picture, which will be divided into small cells. There are multiple pixels in each cell. For every group of each cell, a histogram of gradient directions is computed. The HOG feature is formed by concatenating all the histograms over all the image. For better resolution, HOG contrast is done by calculating the intensity over the largest region of multiple cells, which is named a block, and then this value is used for normalizing all cells within that block. The normalized result gives better performance on the variation in illumination and intensity. The HOG feature returns a real-valued feature vector. The dimensionality of this feature vector is dependent on the parameters chosen for the orientations, pixels per cell, and cells per block parameters. HOG features are extracted from large numbers of facial images to be used as part of the recognition mechanism (Rosebrock, 2021). These HOG features are then labelled together for a face/user and a Support Vector Machine (SVM) model is trained to predict faces that are fed into the system.

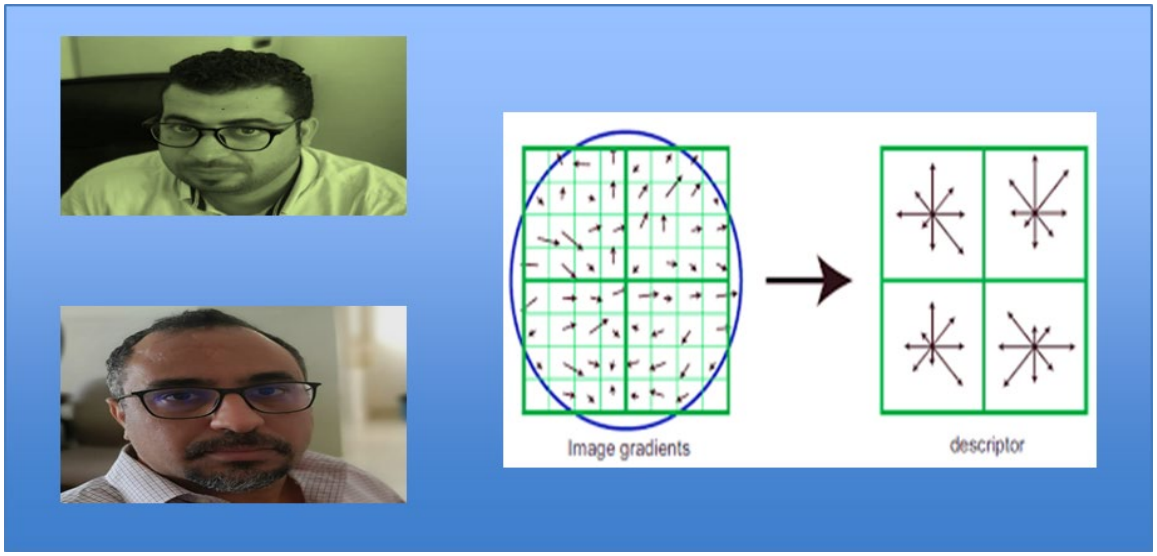

Figure 1. Histogram of Oriented Gradients from different faces

Support Vector Machines

Support Vector Machines (SVMs) are designed to solve the classic two-layer pattern recognition problem (Vapnik, 1998; Fradkin & Muchnik. 2006). SVMs are a set of supervised learning methods used for classification, regression and outlier detection. SVM uses a subset of training points in the decision function, called support vectors. A support-vector machine constructs a hyperplane or set of hyperplanes in a high- or infinite-dimensional space, which

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can be used for classification, regression, or other tasks like outlier detection. Intuitively, a good separation is achieved by the hyperplane that has the largest distance to the nearest training-data point of any class, since, in general, the larger the margin, the lower the generalization error of the classifier. Figure 2 reflects the separation of groups of samples by a hyperplane where the classifier chooses the perfect hyperplane giving the maximum margin between the hyperplane and the nearest sample representing a specific class.

In this paper, we adopt SVM for face recognition by modifying the interpretation of the SVM classifier output and creating representations of facial images that are compatible with a two-layer problem. We are concerned with the following two categories: the differences between images of the same individual; and dissimilarities between images of different people. These two classes are the inputs to the SVM algorithm. The SVM algorithm creates a decision surface that separates the two classes. For face recognition, we re-interpret the resolution surface to produce a measure of similarity between two facial images. This allows us to build face recognition algorithms. We demonstrate the SVM-based algorithm in both validation and identification applications. In identification, the algorithm is presented with a photo of an anonymous person. The algorithm provides the best estimate of the identity of the person from a database of known individuals. In a more general response, the algorithm will present a list of the most similar individuals in the database. In verification (also referred to as authentication), the algorithm is presented with a photo and alleged identity of the person. The algorithm either accepts, rejects or calculates a confidence measure of the validity of the claim (Qutbuddin & Larik, 2021).

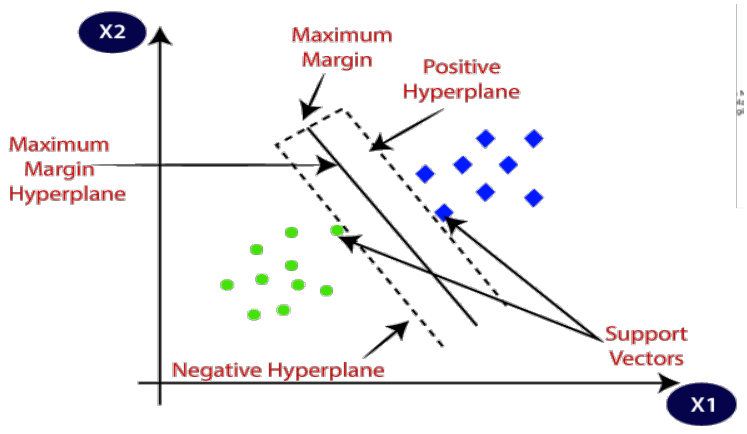

Figure 2. Support Vector Machines

The recognition of faces in the video sequence of the class is divided into three basic tasks: face detection, face prediction, and face tracking. Before starting the process of face recognition, a vector of HOG facial features is extracted. This vector is then used in the SVM model to determine the degree of matching of the input vector with each of the labels. The SVM returns

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the label of the face that represents the confidence to the closest match within the trained face data (Thaware, 2018).

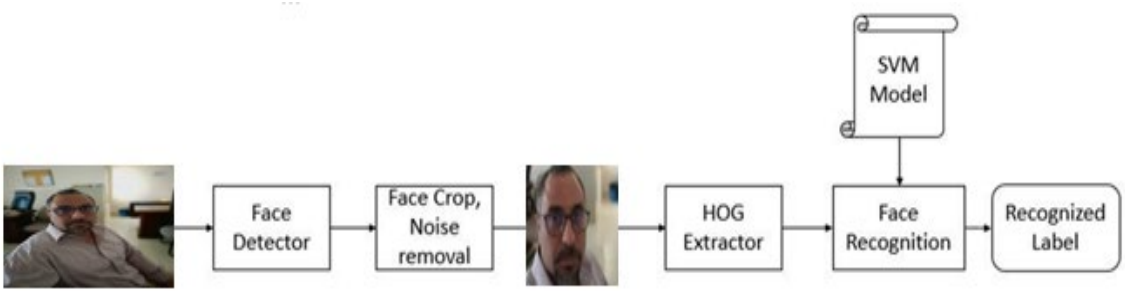

Figure 3. Block diagram of the face recognition process with Support Vector Machines

Methodology

In this paper we propose an accurate and cost-effective smart attendance management system that uses face recognition techniques. Additionally, this system uses a Raspberry Pi to capture and detect the students' faces.

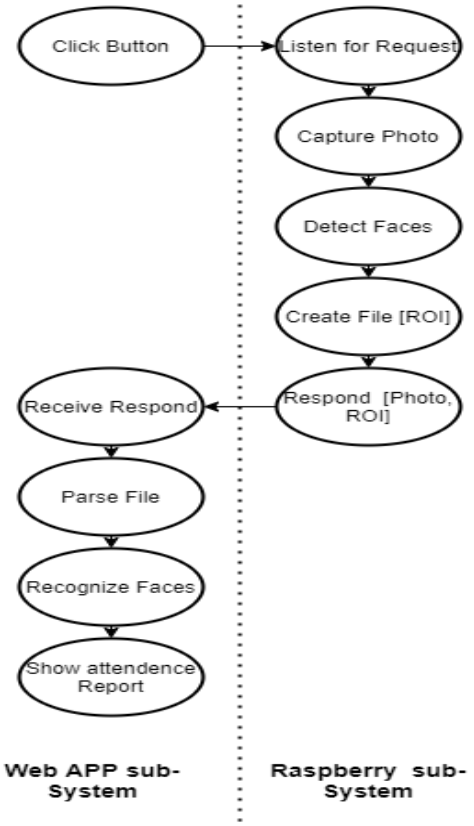

Figure 4. The proposed attendance system workflow

The proposed system is composed of two main subsystems that can communicate together by exchanging relevant data. The first one is a Raspberry Pi system, which is going to be installed

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in each class, and the second one is a web application that will be fed by data sent by the first subsystem.

The procedure is shown in Figure 4. First, an instructor will start a Raspberry Pi camera by pushing a button from the web application (SIS). After that, the Raspberry Pi camera will take a picture of the whole class. This picture will be analyzed locally in the Raspberry Pi system via a script that detects all the faces existing in that image using the Haar feature-based cascade classifier. The output of this script is a file that contains Cartesian coordinates of the detected faces. This file will be sent to the web application to accomplish the face recognition task.

Once the file is received by the web application, it will be parsed and the coordinates of the faces will be fetched. Then for each Region of Interest (ROI), an SVM algorithm is used to recognize the detected face. The recognizer uses the pre-built dataset of that particular class, which contains personal photos of each student in that class saved with their particular name or ID number. Finally, once every detected face is recognized, the web application would update the attendance database and generate a report for the instructor showing the list of students' names along with their attendance status and a timestamp.

Just like any other biometric identification, face recognition requires samples to be collected, identified, extracted with the required information, and stored for a later recognition process. Moreover, the accuracy of face recognition is highly dependent on the quality and variety of the sample images. The variety of sample images can be obtained by capturing multiple images with multiple facial expressions and angles for the same face.

For illustration, Figure 5 shows an example of sample face capture with several emotions.

Figure 5. Sample face capture

In this project, the dataset that is used for training the face recognition model contains 77 images which are stored inside 6 different folders. Each folder holds specific individual photos and is labelled with his/her ID number. Prior to the recognition phase, a model should be trained by applying the SVM algorithm on the images of the dataset. As illustrated in Figure 6, the training phase is achieved in two basic stages, face detection and feature extraction. The detection process is accomplished by applying the Haar Cascade Classifier on the images of all the registered students, then delivering an xml file. Once a face is detected, it can be cropped and stored as a sample face image for analysis and feature extraction.

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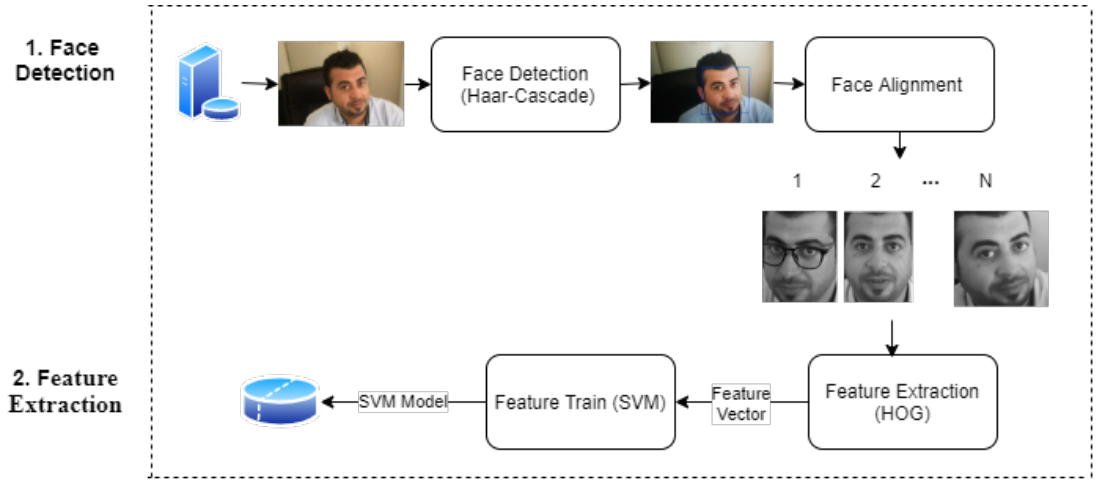

Figure 6. Face Training

After that, HOG (Histogram of Oriented Gradients) features are extracted from all the samples of face images that are related to a particular student. These HOG vectors of features are then labelled together for that specific user, forming an SVM label within an SVM model. As all the facial images of all users are extracted, an SVM model is generated and saved to recognize faces that are fed into the system afterward.

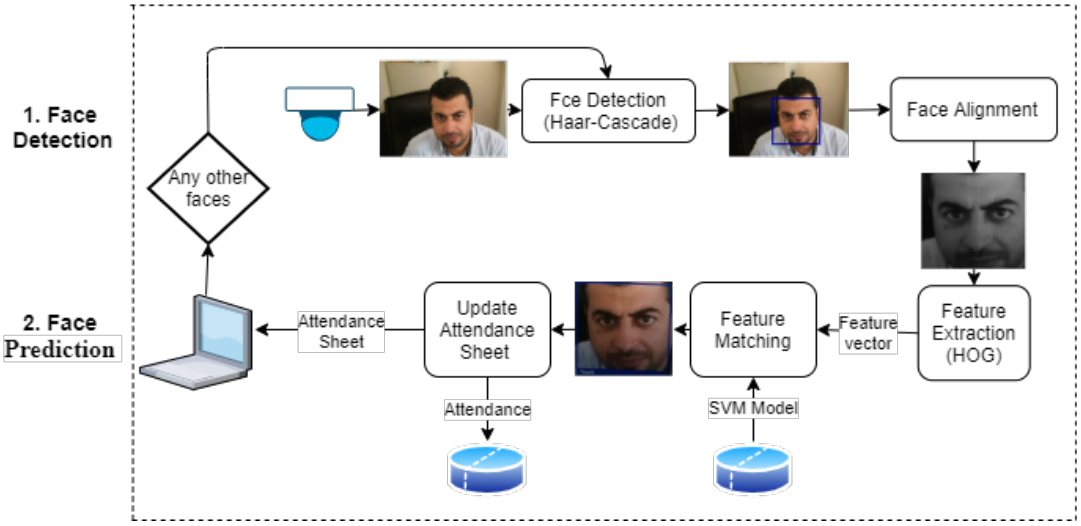

Figure 7. Face Recognition Model

The recognition of a face in an image is divided into two primary tasks, Face Detection and Face Prediction, as shown in Figure 7. The instructor accesses the system (SIS) and clicks a button to start recording the attendance. Accordingly, a request is sent to the Raspberry Pi camera, which is located in the classroom, to open and capture a photo of the whole class. The captured image is then passed through the Haar Cascade Classifier to detect all the faces shown in the photo. The classifier presents a bounding box around the detected faces. Next, the image is cropped to one certain face, normalized and kept as a facial image sample. Afterward, the facial image HOG features are extracted and compared with each SVM label in

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the SVM model to predict the student's label (name/ID). The SVM classifier returns a label with the maximum matching score. Later on, the recognized label is assigned with the presence status in the attendance database. Back at the class photo, the recognized face is now shown with its label. The same process is then repeated with all the detected faces within the captured image. Finally, a completed attendance sheet is viewed by the instructor without his/her intervention.

Results and Discussion

The algorithm used to produce a smart attendance system utilizes the face recognition and dlib libraries besides the HOG method in Python. For the testing and evaluation of the attendance system, two experiments are done: one for measuring the performance of the face detection module; and another one for measuring the performance of the face recognition module, which is highly dependent on the accuracy of the first module.

To measure the performance of the face detection module, 100 images are placed in one folder (70 facial images and 30 not facial images). The results obtained by this test are: 65 True Positive (TP), 27 True Negative (TN), 5 False Negative (FN) and 3 False Positive (FP). Based on the result, the face detection accuracy is estimated using a Balanced Accuracy formula as follows:

$$BA = \frac{1}{2}\,(TPR + TNR)$$

where TPR (true Positive Rate) is given as the Ratio of TP over the P (Positive):

$$TPR = \frac{TP}{P}$$

and TNR (True Negative Rate) is given as the Ratio of TN over the N (Negative):

$$TNR = \frac{TN}{N}.$$

In the above experiment, we get TPR = 92.8 % and TNR = 90 %. Hence, we get an accuracy Rate BA = 91.4 %. Figure 8 shows a sample of true positive outputs and Figure 9 shows an example of a false negative case.

Moreover, a Python script has been created to calculate the face detection accuracy score, the error rate, a drawing of the Receiver Operating Characteristic (ROC) curve, and the area under the ROC curve (AUC), based on the above results.

Figure 10 shows the plotted ROC curve along with the AUC percentage for the face detection module. The ROC curve shows the trade-off between sensitivity (TPR) and specificity (1 –

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FPR). The blue dash line represents a random classifier where FPR = TPR. The orange curve symbolizes our face detection classifier. Generally, classifiers that give curves closer to the top-left corner indicate a better performance (with higher TPR and Lower FPR). Thus, the orange curve denotes a great classifier for face detection. Similarly, we can indicate that an AUC = 0.8 summarizes the performance of the classifier.

Figure 8. Correctly detected faces (True Positives)

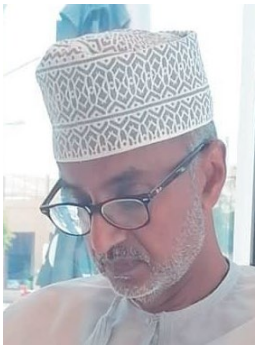

Figure 9. Incorrectly detected face (False Negative)

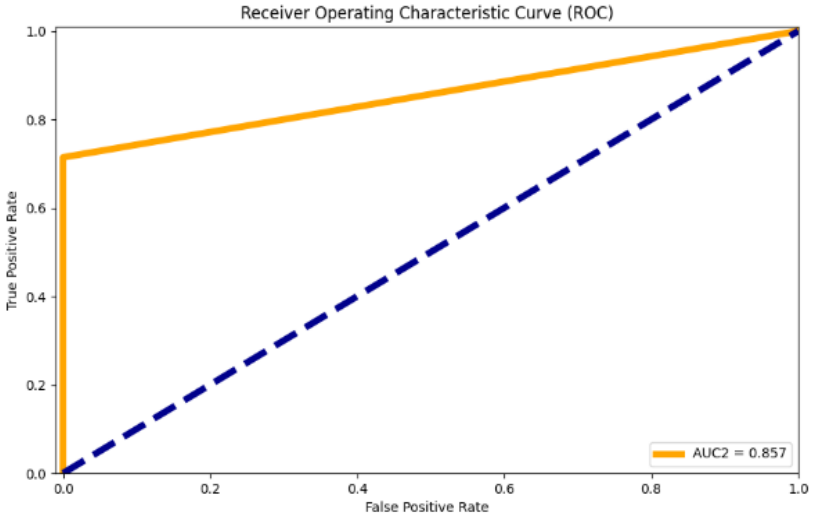

Figure 10 Face detection ROC curve

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To test the face recognition module of the attendance management system, we placed in a folder 8 images of 8 different faces. Five of these images are of persons who have been used for the training of the model while the rest are of other persons (which means unknown to the system). In this particular experiment, TP stands for a correctly recognised face; TN stands for a correct unrecognised face classified as "unknown"; FP stands for an unknown face recognised as existing in the class; FN stands for a face in the class classified as "unknown". A special concern here is to minimize the FN rate due the fact that the attendance system will mark the student as absent when he/she is present, which should be avoided if deployment of the system is to be considered in the near future.

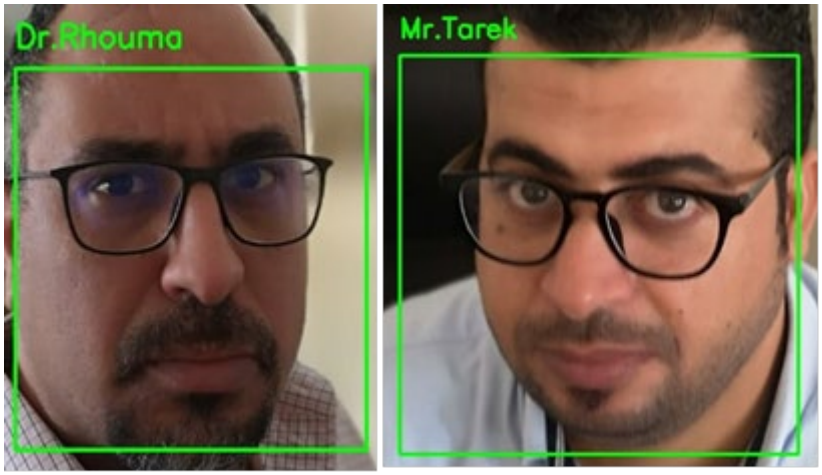

Figure 11. Correctly recognised faces (True Positives)

The obtained result indicates 5 TP, 1 TN, 0 FN and 2 FP. These values give a balanced accuracy of BA = (TPR + TNR)/2 = (100 + 33.3)/2 = 66%; but note that FNR = 1 – TPR = 0%, which is the most important feature that we need to accomplish. Figure 11 displays a sample of true positive outputs. Consequently, Figure 12 shows an example attendance.json file updated according to the recognized faces. Additionally, Figure 13 shows an example of a true negative output.

Fig.14 shows the plotted ROC curve along with the AUC percentage that reflects the face identification efficiency. The face recognition classifier (orange curve) demonstrates a good performance with AUC = 0.6.

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```
[
{
"name": "Mr.Mickel",
"status": "present"
},
{
"name": "Dr.Brown",
"status": "present"
},
{
"name": "Mr.Layeeq",
"status": "absent"
}
]
```


Figure 12. An example attendance.json file

Figure 13. True negative output

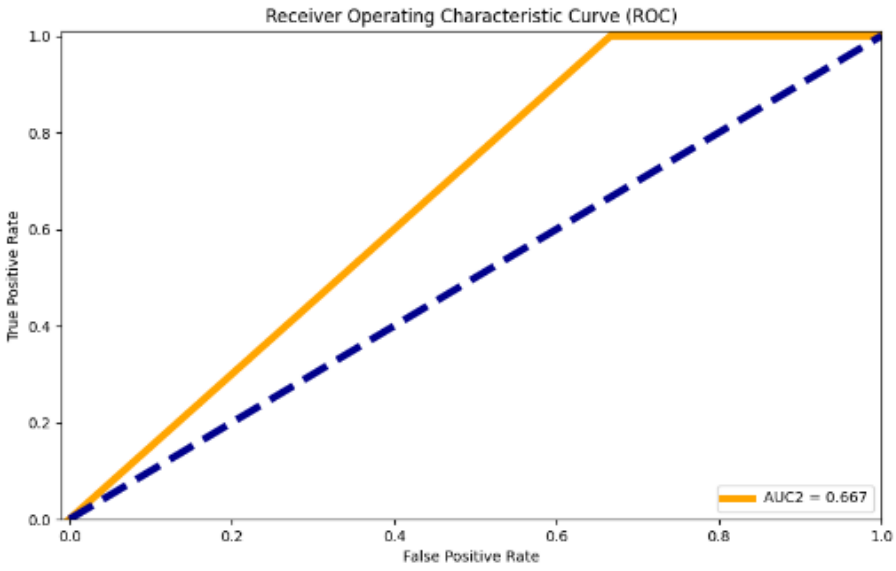

Figure 14. Face Recognition ROC curve

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Conclusion

The attendance system that we have designed using a Raspberry Pi, Python programming, machine learning/deep learning libraries and Django web Framework, needs further work regarding the SIS system which is the front-end for the instructor. Switching to a semi-automatic attendance system can gain time spent in every class marking the attendance register manually by calling students one by one. However, one should recheck the results since no system is 100% efficient. The recognition phase can be done by using another algorithm besides HOG/SVM like HOG/Deep Learning approach.

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Effective Optimization of Billboard Ads Based on CDR Data Leverage

Imed Eddine Semassel
Department of Computer Science, Faculty of Sciences of Tunis, El Manar University, Tunis, Tunisia

Sadok Ben Yahia
Department of Software Science, University of Technology, Tallinn, Estonia

Abstract: Call Detail Records (CDRs) provide metadata about phone calls and text message usage. Many studies have shown these CDR data to provide gainful information on people's mobility patterns and relationships with fine-grained aspects, both temporal and spatial elements. This information allows tracking population levels in each country region, individual movements, seasonal locations, population changes, and migration. This paper introduces a method for analyzing and exploiting CDR data to recommend billboard ads. We usher by clustering the locations based on the recorded activities' pattern regarding users' mobility. The key idea is to rate sites by performing a thorough cluster analysis over the achieved data, having no prior ground-truth information, to assess and optimize the ads' placements and timing for more efficiency at the billboards.

Keywords: Call Detail Records, Rating scores, Outdoor advertising, Billboards

Introduction

In daily lives and around the world, mobile usage is exploding, and telecommunications services account for over 5 billion unique subscribers with access to mobile devices (Letouzé & Vinck, 2015). Indeed, almost ninety percent of people have mobile phones. These latter are moving, and arguably they are leaving tracks of their movements, which can generate extensive data and information. The data of telephone calls or other communication like Short Message Services (SMS) that passes through such devices are recorded by a Telecom Service Provider and referred to in the remainder of this paper as Call Data Record (CDR). The latter is a data structure storing information about a given telephonic activity involving a user of a telephonic network. A CDR usually contains spatial and temporal data.

It is a real challenge to obtain valuable data to elaborate accurate statistics. In this context, the emergence of new types of data, or metadata, collected passively from the population and

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anonymized to make them compliant for secondary use and the strict requirements of the General Data Protection Regulation (GDPR) of the European Union presents a genuine opportunity. Furthermore, they can complement self-reported data from interviews and questionnaires, which are time-consuming, laborious, and tricky to predict the dynamic changes. CDRs are among these passively collected data and are steadily being used in research and other big data forms (Cuzzocrea, Ferri & Grifoni, 2018).

On the socio-economic side, mobile phones are considered the preferred and most accessible means of communication (CTA, 2017). The lack of reliable landline infrastructure explains this preference. Besides, they play a pivotal role in socio-economic evolution (Arie, 2015). By deploying mathematical modelling techniques, researchers can explore issues that heavily rely on CDR data to gauge insights into the location of different populations and their evolution over time (Gore *et al.*, 2019; GSMA, 2017).

By their nature, CDRs are generated in large volumes. They can be seen as a wide-area sensor network as long as they offer a statistically accurate representation of the distribution of people in an area. They can be integrated with other sources to track large and heterogeneous groups of people (Bianchi *et al.*, 2015). Telecom operators continuously gather an immense quantity of CDRs, from which it is possible to extract additional information with low additional cost and generate valuable datasets. We can derive gainful knowledge from analyzing these data, which may help in city planning (Steenbruggen, Tranos & Nijkamp, 2015; Louail *et al.*, 2014), such as marketing, user profiling, disease spreading patterns, natural disasters, social event occurrence, and their impacts.

Mining mobile phone data offers mobile telecommunication operators the opportunity to have a two-sided business model. Firstly, they would generate revenues from their mobile phone users and, secondly, from upstream customers, such as advertising firms (Quercia *et al.*, 2011).

Outdoor advertising has a 500 billion USD global market; its revenue has grown by over 23% in the past decade to over 6.4 billion USD in the US alone (Zhang *et al.*, 2018). Billboards are the most used medium for outdoor advertising (about 65%), and 80% of people notice them when driving (Zhang *et al.*, 2018). A credible way to assess the performance of billboard ads should include both the number of people in front of the billboard and the likelihood that those people might like a specific ad shown on the billboard(Quercia *et al.*, 2011). Billboards have remained a crucial tool for spreading information to a target market. However, due to technological advances and consumer preferences, effective placement and innovative advertising methods are required to capture target customers' attention. Our proposition rates the zones based on the pattern of activities extracted from CDR data. We clustered these latter

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into 3 clusters, and we used results and statistical measurements to provide recommendations about the billboards and their ad content.

We structure the remainder of the paper as follows. First, in the section Related Work, we present scrutiny of the related works. Then, Section Methodology describes our contribution, the dataset we have used, and the results obtained. Finally, we present some concluding remarks and issues for the future work in the Conclusion.

Related Work

Sultan *et al.* (2019) introduced a clustering-based artificial neural network model (C-ANN) to study the operational efficiency of cellular networks and user action patterns using the CDR data, publicly available from Telecom Italia. The proposed solution focuses on the spatio-temporal analysis of CDRs and can model and classify the network traffic patterns. First, they convert the CDR's activity classification from an unsupervised to a supervised multi-class classification problem. Then, CDR activities are classified based on activity levels and spatio-temporal characteristics. The extracted insights shed light on a solid spatio-temporal relation with the actual network traffic patterns and would be gainful in monitoring and optimizing network traffic.

CDR data was also used to estimate the crowd on a free-to-view special event day in the study carried out by Sumathi *et al.* (2018) at the Indian Institute of Science campus. They applied exploratory data analysis and statistical techniques over the records to estimate the participant count. The CDRs related to people who have their home or work in that event location are removed. The obtained results underscored a positive correlation with participant count.

Starting from the CDR dataset of the D4D challenge, Bianchi *et al.* (2016) proposed a framework for identifying patterns and regularities and deriving meaningful information. The latter was of help in understanding users' habits and extracting their characterizing profiles, using two implementations of an unsupervised data mining procedure:

- LD-ABCD: an agent-based algorithm that extracts separated clusters in the data;
- PROCLUS: a subspace clustering algorithm that identifies clusters in a subset of the original feature space.

The method is greedy in computational space and time resources.

Mamei, Colonna & Galassi (2016) presented a method to identify a home, work, and other frequented places of users using CDRs. First, the method spatially clusters the collected CDR events of each user. Then, they weigh the clusters based on the user visiting pattern. Finally, based on a dynamic threshold, the authors select those weighted clusters associated with the

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relevant places. Thus, ground truth information from a fraction of users whose appropriate places were known beforehand was used.

To understand Estonian group mobility, Hiir *et al.* (2019) analyzed the CDR data to identify the social network patterns by modelling the call activity with a graph. The latter's nodes represent the set of call IDs in the dataset, and the edges represent the call activity between them. Furthermore, the authors studied the impact of natural and social events on the calling activity patterns. Thus, a descriptive analysis was carried out in different periods and between counties, followed by analyzing the effects of natural and non-natural events on call activity. They exploit natural events to inspect the impact of weather and the full moon. Non-natural events are used to inspect how a significant football match affected people's activity. Results showed that the calling activity depends on the calling time period, and that these events do impact it.

Another study by Scharff *et al.* (2015) analyzed CDRs to understand mobility patterns before, during, and after a large religious festival in Senegal called the Magal of Touba. The study investigated mobility and transport patterns by analyzing the changes in communication volume between the city of the festival and other locations in Senegal. It showed the primary routes used by the pilgrims and their respective travel times, with insights into the areas most pilgrims were coming from. Health officials and other stakeholders can underpin these findings to control and stop the spread of infectious diseases by providing information about health structures available during the festivals.

Nair, Elayidom & Gopalan (2020) proposed a method to estimate the traffic density using the global K-means clustering algorithm and K-nearest neighbour classification algorithm. The technique used the CDR data to distinguish traffic density in five different locations on weekdays and weekends. The method clusters the CDR data into a group of data that goes through a classification process to classify and sort the density of the traffic, whether empty, low, high, or complete.

The proposed approach of Leng, Zhao & Koutsopoulos (2021) infers an individual's home and workplace based on the behavioural patterns at various places. The method takes advantage of the mobile phone dataset's behavioural data. Unsupervised machine learning algorithms were utilized to uncover similarities across locations for multiple groups of individuals to infer home and workplace. The approach was tested on a real-world dataset in one of China's most populous cities.

The proposed unsupervised statistical method in DeAlmeida *et al.* (2021), Energy-based Flow Classifier (EFC), detects anomalies in CDR data using a classifier based on the inverse statistics of the Potts model. Abnormalities are not detected using the clustering algorithm.

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However, K-means clustering is used to characterize and analyze the traffic patterns of each region. Telecom Italia provided actual traffic data from Milan, which was used to test the approach. The findings showed that taking into account the varying traffic patterns of different geographic locations is critical in determining the accuracy of anomaly detection in mobile networks.

All these works aim to gauge the crowds of places, either by observing the changes in the CDR activity or classifying the sites based on the users' behaviour and call activity. The results provide worthy insights that can improve many fields, including the effectiveness of outdoor advertising. Table 1 summarizes these works and application domains.

Table 1. Related work and applications

Reference	Year of publication	Dataset country	Dataset year	Method	Application
(Bianchi *et al.*, 2016)	2016	Ivory Coast	2012	Clustering algorithms	profiling users, marketing strategies
(Sultan *et al.*, 2019)	2019	Italy	2013	Clustering-based artificial neural network model	profiling users to monitor the mobile traffic
(Sumathi *et al.*, 2018)	2018	Bengaluru city	2013	Statistical techniques (linear regression)	measuring event success and outdoor advertising.
(Mamei, Colonna & Galassi, 2016)	2016	Italy	2012	Clustering algorithm (K-means).	identify users' relevant places, understand mobility patterns, manage mobility
(Hiir *et al.*, 2019)	2019	Estonia	2015	Social network analysis	identifying human behaviour, understanding the social fabric of events
(Scharff *et al.*, 2015)	2015	Senegal	2013	statistical techniques (frequencies with geographic plots)	Health, Transport, resource management
(Nair, Elayidom & Gopalan, 2020)	2020	India		Global K-means and K nearest neighbour	Density traffic
Leng, Zhao & Koutsopoulos, 2021	2021	China	2004	K-means, Fuzzy C-Means clustering	User Location Segmentation

http://doi.org/10.18080/jtde.v10n2.527

Reference	Year of publication	Dataset country	Dataset year	Method	Application
DeAlmeida *et al.*, 2021	2021	Italy	2013	Unsupervised statistical method	Anomaly detection in mobile networks

In our work, we pay heed to two complementary aspects. We cluster the places based on the recorded activity patterns on the antenna level, which is quite similar to the clustering done by Sultan *et al.* (2019). The difference is that we rely on a mix of the two aspects, spatial and temporal, at the same time. We clustered the areas not only based on their instant activity levels as done in Sultan *et al.* (2019), but also on the patterns of these activities over time, allowing us to extract context information by categorizing them. Furthermore, we compute an hourly rating (RP) point for each place from the activity levels to reflect the spot importance and the effective content type on the ads. Finally, we use these latter data as input for a multi-criteria decision-making model, called TOPSIS, to sort and recommend the billboard places.

CDR Datasets

Mobile phones are ubiquitous in our daily lives as they convey and generate data of actual usage. Therefore, anonymous CDR data can provide dense and rich metadata. That data encapsulates the time and place where any person sends or receives a call and/or a text message. The Sonatel-Orange Telecom company has made CDR data available to the research community as part of the D4D challenge in 2015. The goal is to harness the potential of data from mobile calls to propel socio-economic development. Thus, researchers can investigate several points directly impacting development factors through anonymized CDR datasets.

The considered data are metadata covering the time and place where a user can make a telephone action (call or text message). For example, the Sonatel-Orange mobile operator in Senegal disclosed three triple-anonymized datasets from its mobile users between January 1, 2013, and December 31, 2013, at the occasion of the Data for Development (D4D) in Big Data 2014's challenge (de Montjoye *et al.*, 2014). Below, we briefly describe these datasets.

Dataset 1 represents the traffic per pair of antennas for the 1,666 antennas (sites) hourly. The dataset contains 24 files, of which 12 files contain the monthly voice traffic between the sites, structured as follows~:

- Timestamp: the day and time in YYYYY-MM-DD HH format (24-hour format).
- outgoing_site_id: id of the site from which the call originated.
- incoming_site_id: id of the site receiving the call.
- number_of_calls: the number of calls between both sites during the hour.

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- total_call_duration: the total duration (in seconds) of all calls between the two sites during the hour.

A sample of this dataset is shown in Table 2.

Table 2. Excerpt of data (aggregated phone calls' metadata) from Dataset 1

Timestamp	outgoing site id	incoming site id	Number of calls	Total call duration
2013-01-01 00	1	1	1	54
2013-01-01 00	1	2	1	39
2013-01-01 00	1	24	1	2,957
2013-01-01 00	1	186	1	56
2013-01-01 00	2	2	22	418

Data about monthly traffic text messages between the antennas (sites) are structured as follows:

- Timestamp: the day and time in YYYYY-MM-DD HH format (24-hour format).
- outgoing_site_id: id of the site from which the text originated (SMS).
- incoming_site_id: id of the site receiving the text (SMS).
- number_of_calls: the number of texts (SMS) between the two sites during the hour.

We give an excerpt of this dataset in Table 3.

Table 3. Excerpt of data (aggregated text messages metadata) from Dataset 1

Timestamp	outgoing site id	incoming site id	Number of SMSs
2013-01-01 00	1	61	1
2013-01-01 00	1	340	1
2013-01-01 00	1	419	1
2013-01-01 00	1	420	1
2013-01-01 00	2	447	2

Dataset 2 represents fine mobility data spread per user over an interval of 2 weeks for an entire year. These data are unique in that we pair them with behavioural indicators computed by bandicoot python toolbox at the individual level for about 300,000 users randomly sampled. We give an excerpt of the second dataset in Table 4.

Table 4. Excerpt of fine mobility data (Dataset 2)

user-id	Timestamp	site id
1	2013-01-07 13:10:00	461
1	2013-01-07 17:20:00	454
1	2013-01-07 17:30:00	454
1	2013-01-07 18:40:00	327
1	2013-01-07 20:30:00	323

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Dataset 3 summarizes the rounded one-year mobility data volume (country district level) with behavioural indicators at the individual level for approximately 150,000 randomly sampled users. Table 5 shows an excerpt of the third dataset (district-level mobility data).

Table 5. Excerpt of data from Dataset 3

user-id	Timestamp	district id
37509	2013-01-29 15:00:00	3
84009	2013-01-14 07:00:00	3
84009	2013-01-14 07:00:00	3
84009	2013-01-14 07:00:00	3
80150	2013-01-27 16:50:00	3

Methodology

This section describes in detail our new approach that aims to cluster places and then label them based on CDR data made available by the Sonatel-Orange Telecom company as part of the D4D challenge in 2015, and rate these places with scores that reflect their importance in an advertisement context. We rely on antenna positions and the fine mobility data spread per user over two weeks to generate activity patterns.

The overall system model presented in our contribution comprises three stages, and its workflow is flagged in Figure 1:

- Data pre-processing and analysis step,
- Clustering step,
- Results leveraging step.

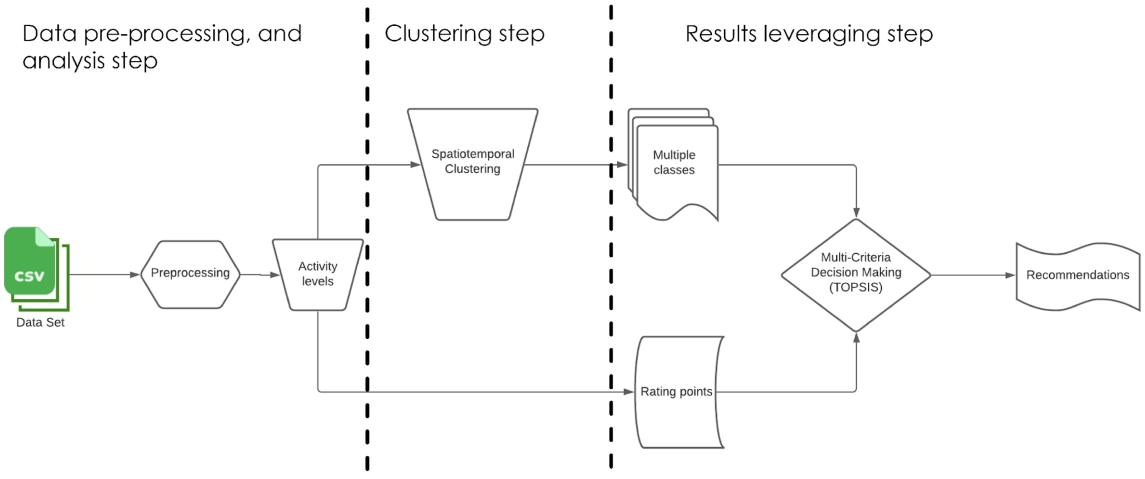

Figure 1. The workflow of our contribution

First, we pre-process and analyze the Dakar Region districts we focused on to get a global overview. We split the Dakar region into ten districts: each district showed a distinct pattern during the two-week period under analysis. According to the CDR activity level recorded for each day, the districts can be labelled by three different labels: high, medium, and low activity

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areas. Our fine-grained work applies to one district with a high activity level (e.g., the DAKAR PLATEAU, id=4 in Figure 2). We notice a sharp decrease in weekends compared to the rest of the week in the latter.

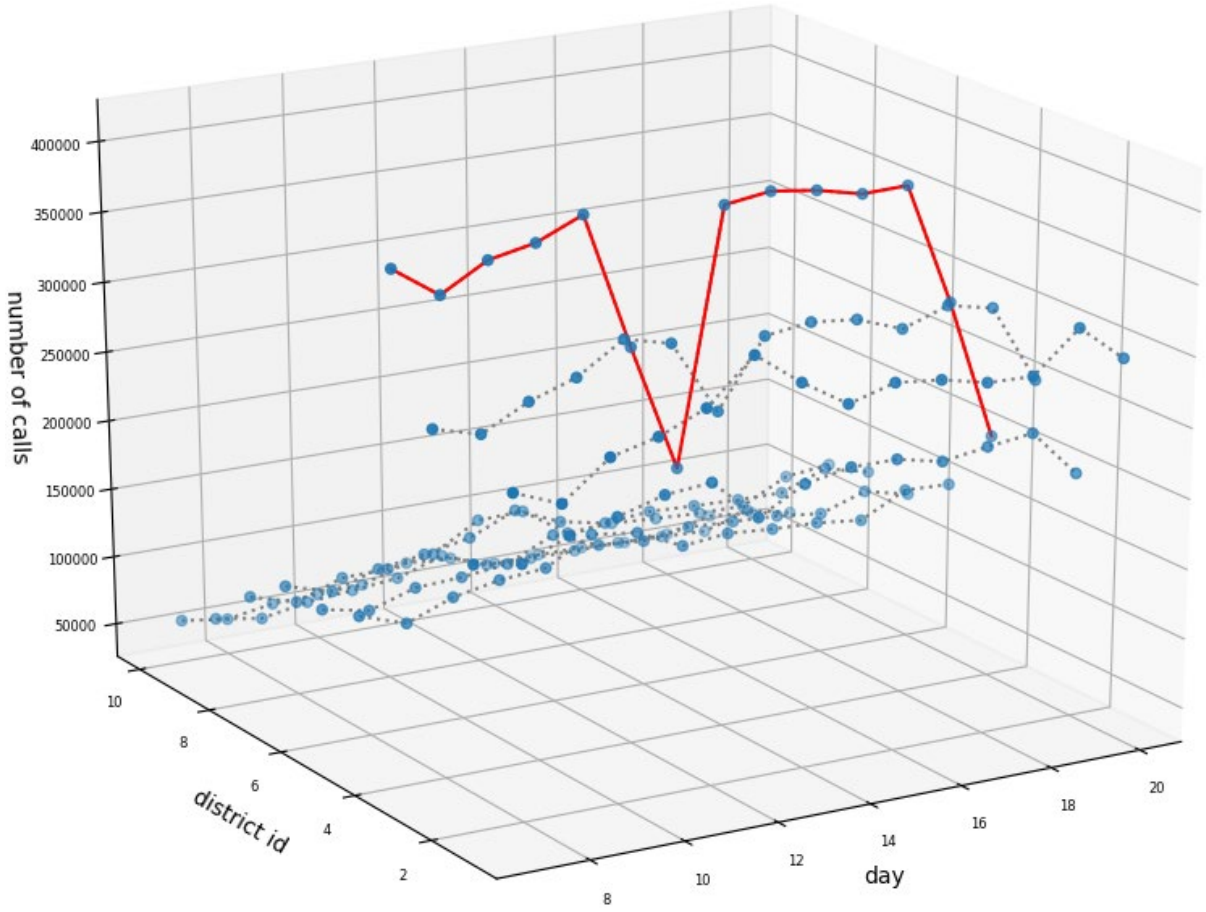

Figure 2. 3D plot of the relationship between the days and the activities at the district level

Then, as an outcome of the Clustering step, the antenna spots are clustered according to the CDR activities' patterns at the hours level into multiple clusters. Finally, the clustering results and the rating points computed from the activity counts are used as input for the TOPSIS model to sort and provide recommendations about the placement of ads and their content types. We perform the clustering step to categorize the antenna spots and transform the rating points from global to targeted rating scores.

Data pre-processing and analysis step

This first step aims to analyze and clean the data. We have analyzed the fine mobility data of the first two weeks recorded in Dataset 2 of the CDR data. We have paid heed to the Dakar Region; we made a 3D plot to underscore the relationship between days and activities at the district level (Figure 2). The continuous red line is the activity of the district DAKAR PLATEAU (id=4); the other dotted lines are the different districts of DAKAR; the points are the number of the records for each district per day. Observing the latter shows that the activity decreases

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during weekends compared to the other days of the week for the high activity districts, especially for the district with id=4 (DAKAR PLATEAU), where it shows five high counts that refer to the weekdays; and two low counts referring the weekends, which is similar to the work pattern.

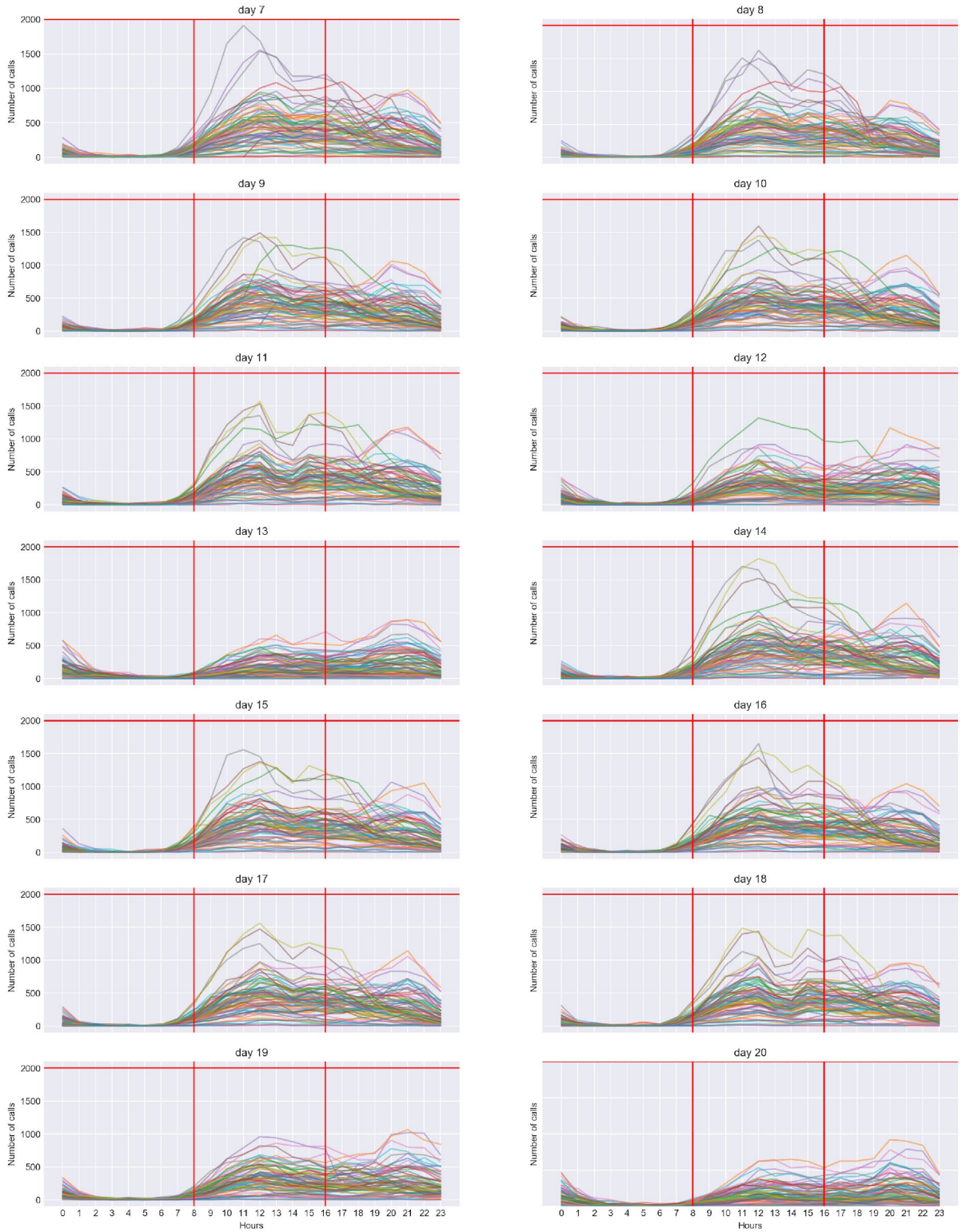

Figure 3. The activity of the district DAKAR PLATEAU of each antenna per hour. Each coloured line represents a different antenna plot.

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We increased the granularity level by analyzing the activities per hour to have more fine-grained results. We have plotted for each site the number of activities/hours daily for both weeks (Figure 3). The vertical red line refers to the 8 am – 4 pm period for each day. (This interval is chosen to flag the differences in activities before, during, and after the working time.) The following facts are worthy of mention:

- shallow activity between 3 am and 6 am for all the antennas, where most people are asleep.
- Low activity at the weekend (day 13 and day 20) compared to other days.
- High activity between the vertical red line in Figure 3 represents 8 am – 4 pm, and several antennas showed their peak on all the days after 4 pm.

These observations assumed that the areas where the antennas belong could be clustered based on the activity pattern. Then, these latter can be labelled by type according to the average patterns of each cluster. For example, areas with top activity during the day and low at night on workdays can refer to a workplace, while areas with high activity at night can refer to urban places.

Clustering step

We cluster the sites according to the CDR activity pattern recorded in each antenna to group sites with similar patterns, using no ground-truth information about the location type of the antennas. We have used unsupervised machine learning algorithms, such as K-means, Gaussian mixture and Agglomerative clustering (Ficek *et al.*, 2012; Jin *et al.*, 2010; Murphy, 2013). These latter are the most popular clustering algorithms that can analyze and group similar unlabelled data into clusters. However, these algorithms require the number of clusters k to be generated; to determine the optimal number of clusters, we have used the silhouette score method (KMeans, 2020). The latter is used to measure the quality of clusters created using clustering algorithms in terms of how well samples are clustered with other samples that are like each other. We computed the Silhouette score for each sample of different clusters and chose its global maximum as the optimal k. For example, the Silhouette score-versus-k plot in Figure 4 shows a clear peak at k = 3. Hence, the data can be optimally clustered into 3 clusters.

In addition to the three algorithms that have shown similar results, we tried to use DBSCAN, which stands for Density-Based Spatial Clustering of Application with Noise. However, the latter did not perform the partition-based clustering and grouped all the antennas in only one cluster. Therefore, we tried an optimized version of DBSCAN named DBSCAN-GM. This combines Gaussian-Means and DBSCAN algorithms to cover the limitations of DBSCAN by

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exploring the benefits of Gaussian-Means. However, it provided the opposite of the DBSCAN results and clustered each antenna in a different cluster.

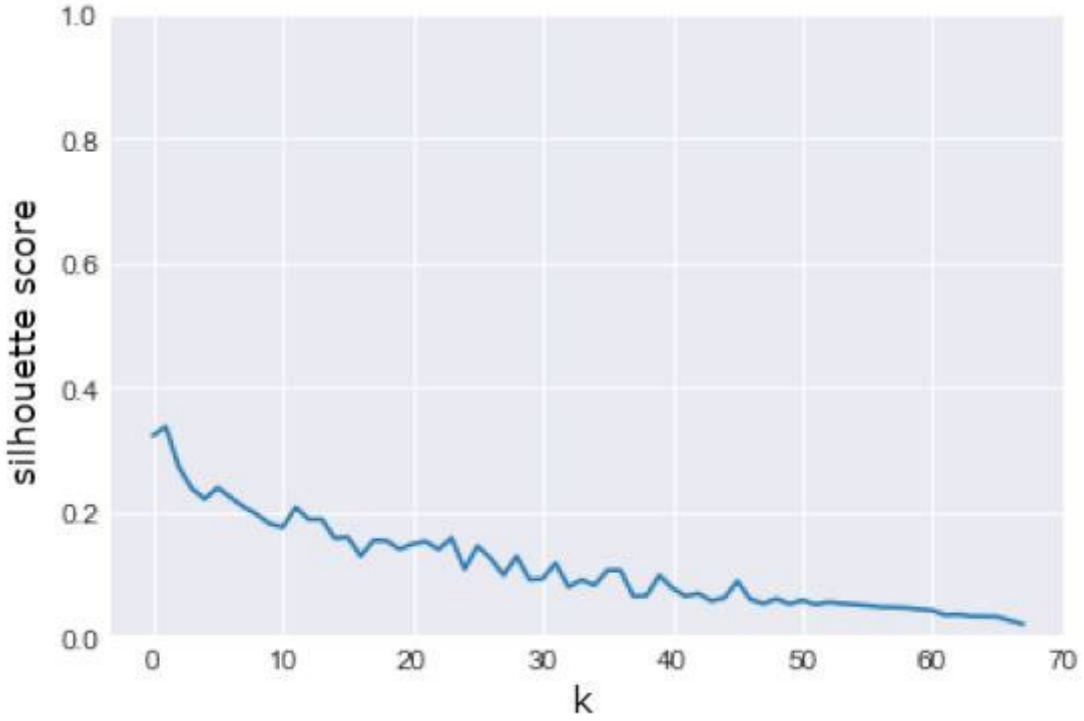

Figure 4. The Silhouette score-versus-k plot

To validate the clustering results, the antennas' activity is plotted as points in a 2D plane using a popular dimensionality reduction algorithm called t-SNE. We have selected this tool to validate our clustering, as it can visualize the antennas' activities, which are high dimensional data, in a two-dimensional map. Then, the antennas' activities are coloured according to the cluster they belong to (we show the results found by K-means).

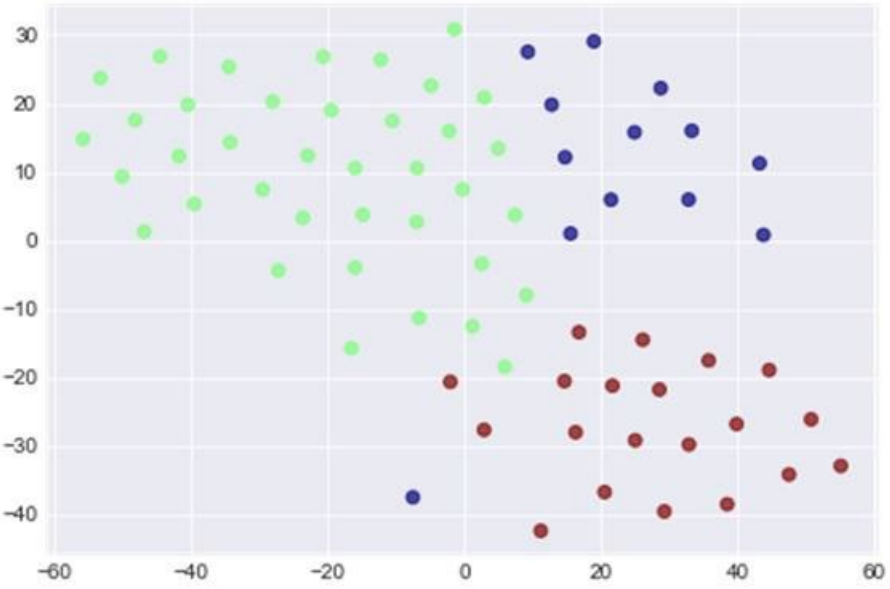

Figure 5. T-SNE Visualisation Validation of K-means results

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In the plot (Figure 5), each point represents the activity of the antennas during the two weeks (336 hours). They were reduced from 336 to 2 dimensions. Theoretically, the distance between points in the higher dimensional space was preserved, so close points refer to similar antenna activity. The fact that most blue, red, and green points are close together indicates that the clustering worked well.

The clustering of the activity of the antennas during the two weeks into 3 clusters is shown in Figure 6 (we show the results found by K-means). Each curve in the plots represents the activity of an antenna during both weeks. The dashed curves represent the mean activity of each cluster, the vertical red line refers to the 8 am – 4 pm period for each day, and the horizontal red line refers to 1000 calls to flag the differences between plots. Each cluster shows a different global pattern:

- **Purple plot**: all the activities are average, and the spikes are after 16h during both weeks, including weekends.
- **Red plot**: where spikes are higher and within 8 am to 4 pm, and at weekends shows shallow activity compared to weekdays.
- **Green plot**: shows low activity compared to two of the other clusters.

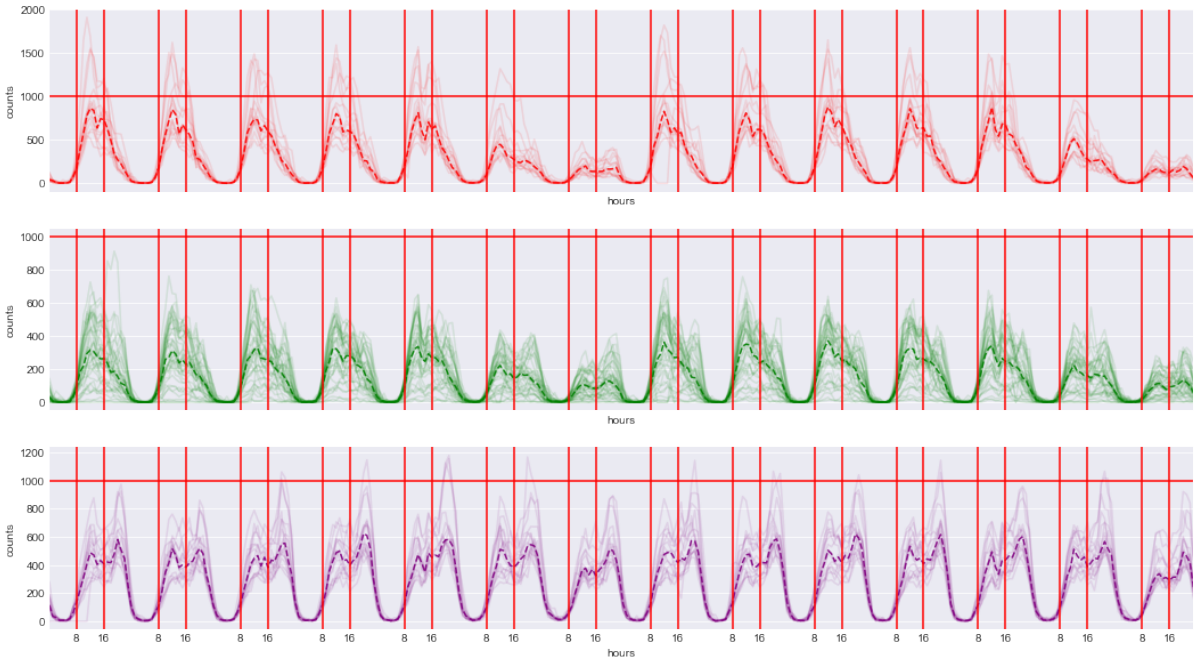

Figure 6. Activity grouped by the identified clusters

According to the patterns shown by the curves in the plots, we can label the clusters as follows:

- **Urban places** for the purple plot,
- **Workplaces** for the red plot,
- **Other places** having infrequent visits for the green plot.

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Results leveraging step

Our next step is to leverage these results. First, we created a map that shows the places based on their type (work, urban, other types), as shown in Figure 7. Since we do not have the antenna coverage area, we have chosen to apply the Voronoi diagram to have a cell for each antenna that simulates its coverage area. Its colour represents the cluster where the antenna belongs.

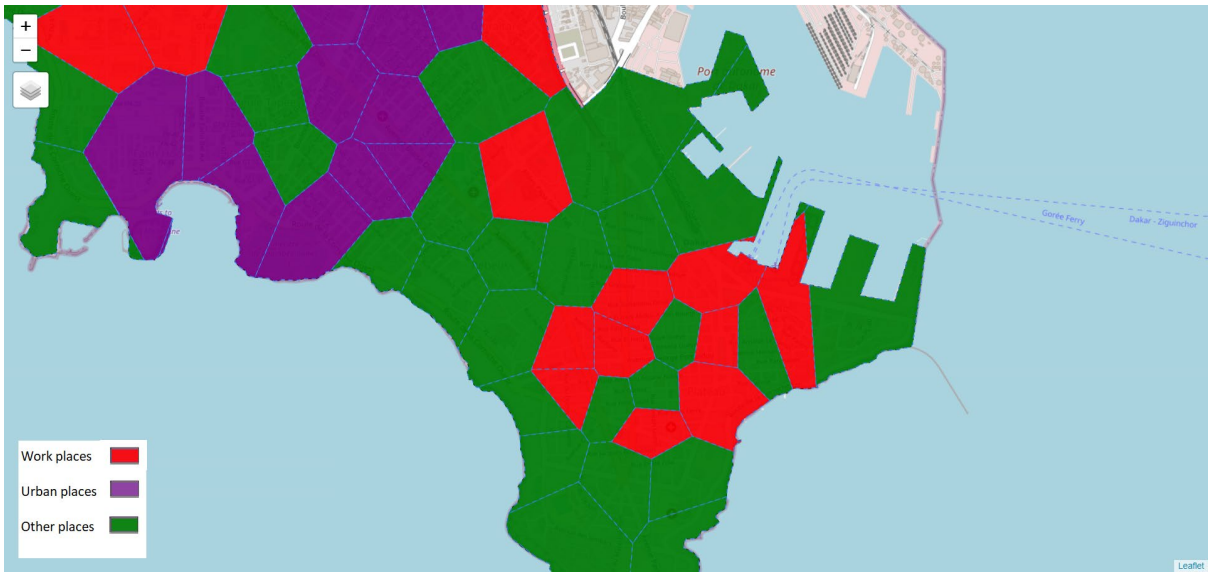

Figure 7. Labelling of the areas according to the identified clusters using the Voronoi diagram to assess the antenna's coverage

Compute rating points

To compute the audience size that reflects the area's importance to the billboard ads, we rely on the Gross Rating Points (GRP) measurement. This latter measures the impression concerning the number of people in the audience for an advertising campaign (Gross Rating Point (GRP), 2020). It is computed by multiplying the percentage of the audience reached by an advertisement with the frequency they see it. Based on this measure and using data extracted from the antenna activity, we compute these scores as follows:

$$RP = Reach\ (\%\ of\ audience\ reached) \times Exposed\ (number\ of\ User\ exposure) \times Frequency\ (number\ of\ ad\ impressions)$$

An RP score for each antenna includes the following parameters:

- **Reach value** stands for the number of users at a given hour, divided by the total number of users that passed by these antennas.
- **The exposed value** is the average number of how many recorded CDRs there are for users at a given hour and antenna. (We added this value to gauge the number of times the user is exposed to the ads.)

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- **The Frequency value** is the number of exposures of the ad, which can vary from 1 to the number that the advertiser allocates.

Using technique for order preference by similarity to ideal solution (TOPSIS)

After computing rating points for each antenna per hour using the formula presented in the previous section, the rating points are used as input to a Multi-Attribute Decision Making (MADM) method named TOPSIS. The TOPSIS model is a MADM method widely used for ranking alternative candidates based on multiple attributes. In our work, we set the hours as attributes and the antennas, which represent areas as alternatives, for sorting and selecting the best placements for the billboards for each cluster based on the scores computed.

Table 6 shows the matrix with the computed scores (rating points) for each antenna per hour, which is the input for the TOPSIS model. For each antenna, we calculate 24 values using the formula. Each value reflects the rating point of an antenna for one hour based on its recorded activities. Table 7 shows the ranked antennas with the scores computed with the TOPSIS model.

Table 6. The input matrix of urban places for the TOPSIS model
Part 1

Attributes (time)	Alternatives (Sites)							
	82	**104**	**106**	**109**	**128**	**130**	**132**	**140**
0h	62.18	56.42	31.97	35.66	18.98	34.01	36.44	15.39
1h	24.12	21.67	13.95	15.14	8.88	12.25	14.99	6.40
2h	12.44	9.60	5.93	5.52	4.77	3.98	5.09	3.31
3h	5.86	3.66	3.05	3.80	3.13	2.32	1.95	1.47
4h	2.95	2.73	1.95	3.02	2.05	1.41	1.59	1.20
5h	2.65	1.78	1.31	2.59	1.91	1.57	1.23	0.91
6h	5.18	3.48	3.08	3.26	2.14	2.55	4.50	1.43
7h	17.76	13.43	9.34	9.70	8.65	8.21	11.57	5.22
8h	35.39	26.69	21.22	17.15	23.79	15.73	20.22	11.28
9h	57.28	44.19	37.42	29.45	45.98	31.89	35.12	22.19
10h	77.52	71.40	54.29	42.23	68.35	48.54	53.94	34.19
11h	96.13	88.72	68.15	53.05	78.90	57.51	67.64	43.70
12h	123.12	111.15	80.94	64.60	91.67	72.14	79.97	51.81
13h	112.75	110.82	76.58	64.14	79.98	73.79	81.11	49.07
14h	97.22	100.79	71.36	65.23	69.21	73.00	81.82	44.28
15h	93.87	99.99	76.34	67.98	73.11	78.64	81.47	45.16
16h	90.53	99.07	75.74	64.97	62.87	74.21	74.63	44.04
17h	90.53	100.64	76.89	74.38	60.60	74.98	77.34	49.73
18h	104.42	111.91	80.93	80.07	58.45	78.71	86.71	49.92
19h	130.14	130.99	89.68	87.87	64.00	96.32	111.32	56.09
20h	148.03	165.37	106.49	95.35	73.53	111.72	140.68	59.79
21h	157.33	167.41	107.22	100.08	71.25	111.26	153.02	50.90
22h	148.42	151.96	92.18	87.60	58.76	99.71	130.16	41.65
23h	106.12	110.66	65.28	70.93	39.90	72.01	87.67	29.22

Part 2

Attributes (time)	Alternatives (Sites)							
	147	**155**	**161**	**163**	**165**	**170**	**177**	**188**
0h	27.13	29.24	35.06	17.97	18.68	15.60	27.45	14.81
1h	10.36	11.88	12.48	7.07	7.30	5.02	10.54	4.74

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Attributes (time)	Alternatives (Sites)							
	147	**155**	**161**	**163**	**165**	**170**	**177**	**188**
2h	3.19	3.82	3.69	2.74	3.31	1.82	4.25	1.92
3h	1.72	2.46	2.00	1.32	1.84	1.09	1.40	0.77
4h	1.07	1.17	1.14	0.92	1.25	1.07	0.77	0.64
5h	0.89	1.38	1.39	0.84	1.03	0.72	1.03	1.12
6h	2.45	2.26	2.93	1.57	1.55	1.54	2.33	2.23
7h	7.89	8.20	9.36	5.56	5.83	6.83	8.20	9.81
8h	14.39	17.56	23.34	16.24	12.59	13.39	16.07	20.11
9h	27.79	32.98	36.15	33.45	24.34	23.25	31.13	37.08
10h	39.22	51.73	54.98	50.43	38.55	34.77	42.96	49.58
11h	51.72	63.00	66.81	65.12	48.33	42.60	54.65	59.84
12h	64.45	67.21	76.00	74.15	53.68	51.56	59.96	66.51
13h	62.77	63.66	75.02	72.48	53.23	46.37	61.19	64.17
14h	60.62	60.29	69.34	61.95	49.24	41.90	54.28	55.08
15h	65.10	66.04	75.36	69.39	52.68	41.63	57.30	57.27
16h	60.61	60.84	69.82	65.82	51.99	39.87	55.59	54.32
17h	65.78	68.51	77.93	69.10	56.08	42.70	56.57	55.10
18h	65.29	67.96	78.58	68.65	55.95	42.55	59.54	51.28
19h	71.67	87.32	96.14	69.66	64.68	51.60	72.15	54.74
20h	83.67	111.22	126.07	71.26	65.12	58.09	91.13	61.70
21h	83.14	115.95	132.09	66.65	65.72	54.64	95.91	58.90
22h	76.41	98.06	113.53	58.95	54.40	47.72	79.71	47.40
23h	54.35	63.54	78.82	40.30	37.15	33.70	52.83	31.22

Table 7. Urban places ranked antennas based on TOPSIS scores

Antenna	**82**	**104**	**132**	**109**	**106**	**161**	**130**	**128**
Score	0.95	0.76	0.50	0.48	0.45	0.41	0.38	0.37
Rank	1	2	3	4	5	6	7	8
Antenna	**155**	**177**	**147**	**163**	**188**	**165**	**140**	**170**
Score	0.33	0.24	0.23	0.20	0.17	0.14	0.09	0.06
Rank	9	10	11	12	13	14	15	16

Discussion

The TOPSIS results for each identified cluster can help in setting up a reasonable pricing system, where the price that advertisers pay depends on two aspects (the type of place according to the clustering and their rank according to the size of the audience), which is a more precise valuation. Moreover, our clustering is quite similar to the clustering done by Sultan *et al.* (2019). The difference is that we cluster the places based on the patterns of the recorded activity on the antenna level, while paying heed to the spatial and temporal aspects at the same time. The antennas and their estimated coverage handle the spatial aspect. The temporal aspect is handled by the number of the recorded activities for each hour. Unlike Sultan *et al.* (2019), we rely on combining the two aspects. We clustered the areas considering their instant activity levels and the patterns of these activities during a period of time, allowing us to classify the areas as urban, work, and other places.

Furthermore, the final results can also provide recommendations that can optimize the efficiency and the impact of the ads and help in the control and placing of the billboards through a dashboard. Among these recommendations are:

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- As we ranked places according to the times and spots with a high density of people, we can recommend the places for billboards and advertising;
- As we have the type of places (work, home, other spots), we can recommend how and where the advertisers should place their advertising;
- As we know the transition areas and time and places with low density, we can recommend a set of rules on how the ads should be in these places, especially on highways, to avoid accidents;
- As we have the type of places, we can recommend the type (animation, 3D, etc.) of the content of the ads based on the places and the peak time to increase the efficiency;
- Using rating points along with the type of places, we can recommend the subject of the content of the ads based on the time and spots (return from work, going to work, etc.) to recall products to the consumers and increase the efficiency of the ads;
- Recommend planning the time allocated to the ads and how much they cost based on each place's type and rating point.

Following these recommendations helps advertisers target their audience more effectively by designing attractive ads that consider several parameters. For example, an ad related to food and restaurants in a place labelled as a workplace, around midday, would be very efficient, since thoughts in that area are about lunch, which increases the probability of noticing and being attracted by these ads.

Conclusion

Based on all the observed results, it becomes clear that CDR data analysis can help identify and characterize user trends. In this paper, we presented a method for analyzing and exploiting mobile data. The key idea is to cluster and label the locations based on the pattern of the users' activities recorded by the antennas for two weeks. Besides the clustering, we computed rating points from each antenna's registered user activities. This latter reflects the importance of areas. We have chosen the marketing context, one of several contexts where our method can apply. We focused on the Dakar region district antenna places. The clustering produced three clusters. The clustering results have been used along with RP scores to provide a reasonable pricing system and a set of recommendations. The latter is shown to be beneficial in optimizing the efficiency of the outdoor advertisement. It is also worth mentioning that, owing to the contextual information extracted by this method for each location, we might guide the content of the shown ads on the billboards to be catchier and increase their reachability impact.

We can further develop this work to improve clustering accuracy using multiple data sources. For example, we can use the traffic between antennas to find the relation between places and

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cluster the records according to the user activity level and their visited sites before applying the proposed method.

Moreover, we can add additional attributes to the TOPSIS model to rank places with more context-related conditions. Further, it can be extended by adding event aspects to find their correlation with user mobility patterns. In addition, filtering the users by classifying them according to their movements can improve the results and suggest more recommendations.

Besides improving our method results by modifying inputs, we also use other strategies such as adding Fuzzy Clustering and additional steps in the workflow. The latter can be enhanced by considering the different types of communication (SMS, voice call) in the mobile networks.

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Social Media Data Analytics for Marketing Strategies

The Path from Data to Value

Teissir Benslama
University of Manouba, ESCT, LIGUE, Tunisia

Rim Jallouli
University of Manouba, ESEN, LIGUE, Tunisia

Abstract: The analysis of social media data to extract new insights has attracted much attention, especially in the field of Marketing. Few researchers, however, have studied both the concepts of Social Media Data Analytics (SMDA) and Marketing Strategies. Previous publications have only focused on a particular technique or a well-defined Marketing Strategy in a specific context. To address this gap, this paper aims to explore how Social Media Data Analytics can guide and affect Marketing Strategies, and provide an overview of the range of Social Media Data Analytics techniques related to Marketing Strategies. We conducted a systematic review of 120 papers published between 2015 and 2021 on SMDA in Marketing. The findings are presented in terms of the main social media platforms, publication date, journal quality, social media data types, analytical techniques, fields of application, firm size, and related Marketing Strategies. The SMDA techniques are classified into six categories: Sentiment Analysis, Artificial Intelligence, Data Mining, Statistics, Coding and Modelling, and Simulation. A set of detailed Marketing Strategies guided by SMDA are also presented, as well as an integrative framework mapping how SMDA creates value. The results highlight several SMDA techniques that still lack exploration and outline their relevance.

Keywords: Social Media Data Analytics (SMDA), Marketing Strategies, Systematic Literature Review (SLR), Platforms, Techniques

Introduction

The enormous increase in the use of social media platforms in our daily lives has led to a rapid accumulation of heterogeneous and unstructured data, which shares multiple characteristics specifying Big Data (Bazzaz *et al.*, 2021). To get new advantages and opportunities, researchers from different disciplines have tried to analyze data using several techniques. Today Social Media Data Analytics (SMDA) is becoming an emerging and topical research area (Saggi & Jain, 2018). The main problem facing analysts and practitioners is that traditional analytical

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techniques have become inefficient and sometimes unable to manage this huge amount of data (Kaabi & Jallouli, 2019; Rusetski, 2014). This has created new opportunities, not yet fully exploited, to analyze Big Data in order to discover and extract information that can provide added value in different areas (Toivonen *et al.*, 2019). SMDA is defined as the process of using suitable analytical techniques, methods, and tools to collect and analyze social media data in order to solve specific problems and extract useful insights (He *et al.*, 2015; Wang *et al.*, 2020).

Among different areas, the concept of SMDA is widely applied nowadays, remarkably, in the field of marketing (Rathore *et al.*, 2020; Wang *et al.*, 2020). Despite that, the marketing literature still lacks studies aimed at improving Marketing Strategies through SMDA. It is true that many researchers have tried to adapt and extend analytical methods and techniques for social media data to satisfy marketing purposes, but rarely with a clear outline about the advantages that can be offered by each technique. There is still an ambiguity on the best choice of techniques for each type of data and each Marketing Strategy specifically. Thus, the relationship between SMDA and Marketing Strategies has not yet been sufficiently investigated. This study consists of a systematic literature review aiming to understand how SMDA can create value and provide benefits to Marketing Strategies by answering the following research questions:

Q1: What SMDA techniques and methods have been covered in previous research in the field of marketing?

Q2: Which Marketing Strategies have been mostly guided by these techniques?

Q3: What benefits does SMDA provide for Marketing Strategies?

Q4: What are the most used platforms and data types in SMDA for Marketing Strategies?

This paper is organized as follows: The next section presents the concept of SMDA and its use in Marketing. The second section briefly describes the concept of Marketing Strategy as well as its relationship with SMDA. The third section explains the methodology of this study. The fourth section presents the main findings and results. Finally, in the fifth section, a brief conclusion, limitations and some suggestions for future research are presented.

Social Media: Big Data, Analytics and Marketing

Social Media: A Big Data Generator

Social media allows users to spontaneously share unlimited data (information, images, videos, discussions, etc.) and generate a flow of very large data. For example, in 2021, every 60 seconds, 95,000 Stories were posted on Instagram, 500 hours of videos were uploaded on Youtube, and nearly 70 million private messages were added via Facebook Messenger and WhatsApp (Statista, 2021). Big Data originates from the dynamic and increased use of social

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media and other different sources (Gani *et al.*, 2015). Kitchin (2014) considered that social media data is a source of Big Data defined by a high rate of data accumulation, internal variability, variable veracity, and large volumes of data. In the same way, Bazzaz *et al.* (2021) indicated that social media data is characterized by the 5V's of big data: volume, velocity, variety, value, and veracity. In this context, researchers have generally referred to social media data as "Social Media Big Data" (Lynn *et al.*, 2015). Social media are among the main generators of Big Data and the dependence of users on social media leads to a huge volume of data (Laney, 2001). Stieglitz *et al.* (2018) argued for their use of Big Data literature in social media research by the fact that the two concepts share multiple characteristics. So, to understand how to manage social media data, it is important to know and understand how researchers have analyzed Big Data. In this sense, several recent studies were developed in order to discover the analytical characteristics of social media data that differ from Big Data.

Social Media Data Analytics (SMDA): Definition and techniques

SMDA is the process of extracting intelligence to meet given requirements and goals, through the processing and development of techniques and tools allowing the collection, analysis, reduction, and visualization of social media data (Lee, 2018; Wang, 2020). To analyze this huge data effectively, in order to obtain consistent results, it is important to make the right choice of analysis methods (Lv *et al.*, 2017). Therefore, many new methods and techniques have been widely used in recent years, including artificial intelligence, machine learning, classification tree analysis, regression analysis, genetic algorithms, sentiment analysis, topic modelling etc. (Amalina *et al.*, 2020; Chebil *et al.*, 2021). Based on Stieglitz *et al.* (2018), the main SMDA methods are statistical analysis, social network analysis, sentiment analysis, content analysis, and trend analysis. These methods cover a wide range of techniques that can be used separately or combined appropriately. Galetsi, Katsaliaki & Kumar (2020) have classified these techniques into eleven groups: Machine learning, modelling, social network analysis, optimization, visualization, simulation, data mining, web mining, text mining, forecasting, and statistics.

The application of these techniques to deliver useful information has become a challenge for researchers in several disciplines, especially in Marketing.

Social Media Data Analytics and Marketing

Among several disciplines, marketing is the most affected by the evolution of data (Tdan, 2018). This context has pushed academics and practitioners in marketing to analyze social media data using several analytical techniques. For example, Pepsi and McDonald's used SMDA to derive competitive advantages (Grimes, 2013). Marriott, the multinational hotel

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company, analyzed their own tweets, Facebook posts and Instagram photos to improve their brand presence, as well as guest engagement (Golden & Caruso-Cabrera, 2016). Argyris *et al.* (2020) carried out a study aiming to increase consumer engagement with the brand using deep-learning algorithms to analyze data available on Instagram. Aswani *et al.* (2018) adopted SMDA to provide insights into customer perceptions from Twitter using network and content analytics. Benslama & Jallouli (2020) conducted a literature review to understand how social media data clustering techniques can help marketing decisions.

Social Media Data Analytics and Marketing Strategies

Marketing Strategies: Definition and classification

According to Ritonga *et al.* (2018), a company that does not properly study its marketing strategies risks losing its position in the face of difficult competitive conditions. Marketing strategies represent a path to achieve several marketing benefits (Wong, 2007). Several researchers have tried to find the most appropriate definition for the concept of "Marketing Strategy". According to Elansary (2006), Marketing Strategy is a process that includes all the strategies of targeting, segmentation, differentiation and positioning, to create, communicate and propose an offer to a target market. Vincent (2008) defines Marketing Strategy differently: "Marketing Strategy is the analysis and selection of target markets with the development and maintenance of an appropriate marketing mix to meet the target market's needs". Hong & Nguyen (2020) considered Marketing Strategies as a full plan consisting of all marketing goals. In recent years, several researchers have agreed that Marketing Strategies are not limited to the simple use of 4Ps, which must not operate in isolation, and that the Marketing Mix paradigm still remains valid for the Marketing Strategy concept but, at least, targeting, market segmentation or positioning must be included (Campbell *et al.*, 2020; Daniels *et al.*, 2021; Wong, 2007). In the same context, Armstrong *et al.* (2014) and Campbell *et al.* (2020) considered that Marketing Strategies are structured essentially around five categories: Targeting and positioning strategy; Product, service and brand strategy; pricing strategy; Channel and logistics strategy; and Communications and influence strategy.

In recent years, Marketing Strategy has evolved remarkably in three major directions: Digital, Data analytics, and Developing Markets. The use of new technologies, including SMDA, has profound effects on Marketing Strategies (Grewal *et al.*, 2020).

Impact of SMDA on Marketing Strategies

Using SMDA to improve Marketing Strategies represents an important challenge for researchers. Indeed, in the last decade several studies, in which the SMDA have been applied

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to achieve Marketing Strategies objectives, have been published. To exploit competitive intelligence and to find market knowledge, Kim *et al.* (2016) analyzed textual data from Twitter using natural language processing and lexicon-based sentiment analysis. Pournarakis, Sotiropoulos & Giaglis (2017) analyzed Twitter data using data visualization (Word cloud), Latent Dirichlet Allocation (LDA), and Sentiment analysis to obtain inventory performance for Business-to-Business companies, and to help improve logistics strategy. Zhang, He & Zhu (2017) applied SMDA to identify useful customer knowledge. Marine-Roig *et al.* (2019) used Data Mining to analyze data extracted from travel sites in order to improve branding and positioning strategies in the field of tourism and destination. To help hosts improve their pricing strategies related to their property, Airbnb, the online marketplace, used Artificial Intelligence and Machine Learning techniques (Campbell *et al.*, 2020). In order to evaluate Marketing Strategies through social media, Yunus *et al.* (2020) used Krippendorf's Content Analysis to analyze two Instagram accounts of Grab, the most known online transportation provider application in Southeast Asia.

Although there are several articles talking about SMDA for a particular Marketing Strategy, the literature lacks studies encompassing the impact of SMDA on all types of Marketing Strategies and offering a global view of the analytical techniques that can ensure Marketing benefits. We attempt to fill this research gap through a Systematic Literature Review (SLR) on SMDA and Marketing Strategies.

Methodology

The SLR can identify research gaps and offer opportunities for future research (Paul & Rosado-Serrano, 2019). Such a review seems the most appropriate for the purposes of our study, thanks to its ability to produce a high-quality organization and synthesis of the literature (Wang & Chugh, 2014). The review process itself is "transparent, systematic, and reproducible" (Tranfield, Denyer & Smart, 2003). This review follows a three-step process: data collection, data analysis and data synthesis, as in Ng *et al.* (2020) and Vrontis *et al.* (2021).

Data collection

The search for articles was conducted in two major scientific databases: Science Direct and Emerald. This choice is justified by the fact that these databases offer the greatest coverage and are frequently chosen by state-of-the-art systematic reviews (Vrontis *et al.*, 2021). We identified a set of relevant keywords in relation to the key concepts of our study. Therefore, we used for article research a different combination between these keywords: "Marketing", "Social Media", "Data Analytics" and "Strategies". We limited our search to articles written in

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English, published after 2015 (for topical articles), omitting conference proceedings, books, and other nonrefereed publications.

Then, as widely used in systematic reviews of the literature (Vrontis *et al.*, 2021), we read carefully the titles and abstracts of all identified papers. The review focused only on papers that (1) Mainly discussed SMDA; (2) Were in the context of Marketing and Strategies; and (3) Indicated the used SMDA method or technique. Papers that did not meet one of these criteria were excluded from this review. This step yielded 120 papers.

Data analysis

After filtering and selecting papers, we read the content of each paper in order to extract useful information for our topic (Danese, Manfè & Romano, 2017). For each article, we extracted and specified the used SMDA technique/method, the studied Marketing Strategies, as well as the Marketing advantages offered by the SMDA.

Synthesis

In this step, the extracted data were grouped into eleven background variables: title, author, year of publication, journal, field, firm size, Social Media Platform, Data type, Analytical technique/Method, Marketing Strategy, and major findings. In addition, the obtained Marketing Strategies from the previous step were classified, based on Armstrong *et al.* (2014) and Campbell *et al.* (2020), into five groups of strategies. Likewise, SMDA techniques were categorized into seven groups according to their nature.

Main Results and Discussion

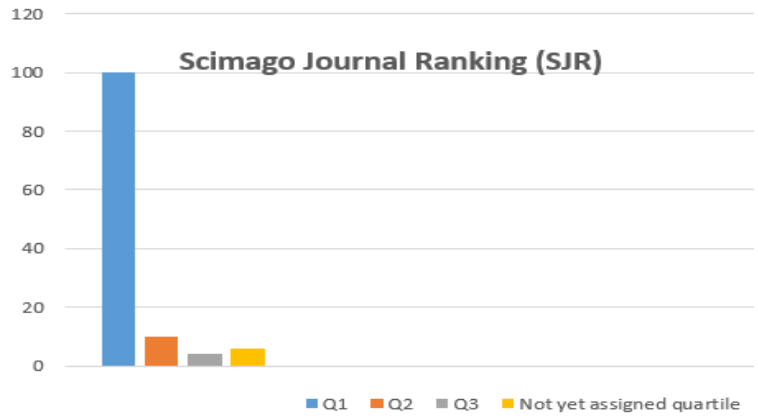

Figure 1. SLR Quality Assessment (Classification of journals according to their SJR)

The distribution of the journals present in our SLR database according to their classification on the Scimago Journal Ranking (SJR) permits us to check the quality of our obtained database (Figure 1). SJR classifies the journals into quartiles, with the first quartile (Q1), which includes journals with excellent and very high impact, and the last quartile (Q4) which

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contains the journals with poor and very low impact. Therefore, we can confirm that our database is of very high quality, since 92% of the journals belong to the first two quartiles (Q1: 100 papers, Q2: 10 papers).

Regarding the size of the studied firms, of the 120 reviewed articles, only 40 indicated the size of the firms, and large companies significantly outperformed SMEs (small and medium-sized enterprises) in the use of SMDA for marketing purposes (89%).

In what concerns the publication date of the retrieved papers, results show that the topics of SMDA and Marketing Strategy won the greatest consideration in 2019 (31 papers), followed closely by 2020 (24 papers). Between 2015 and 2017, there was an upward trend with a slight decrease in the number of articles in 2018 (16 papers). The year 2021 displays a good number of articles although only five articles were found, since we only reviewed articles published during the first three months of the year (Table 1). These results show that SMDA and its impact on Marketing Strategies is an emerging issue that still needs more publications.

Table 1. The number of articles per year

YEAR	2015	2016	2017	2018	2019	2020	2021	TOTAL
FREQUENCY	9	13	22	16	31	24	5	120

The classification of articles according to the fields shows that the most concentrated fields on the application of SMDA for Marketing Strategies are successively: "Tourism, Destinations, Hotels, and restaurants", "Media, Marketing and Advertising Services", "Technology" and "Agri-business and food industry". The other fields are not yet well involved in this process, especially the fields of "Real estate", "Bioenergy", "Entrepreneurship, Start-ups, Employability and recruitment", and "Medicine, health and pharmacy".

Regarding the most used platforms for marketing data analysis, we find in the first place, Twitter, which is used by 60 articles, followed by Facebook (37) and Instagram (13). The other platforms and their frequencies of use are displayed in detail in Figure 2. It is important to draw attention to the fact that the famous professional site LinkedIn was not used by any study in this review.

Figure 2 shows that textual social media data is the most analysed data type with a frequency of 99 out of 120. This shows that other types of data require more attention from researchers studying SMDA and Marketing Strategies. This may be explained by the lack of analysis capacity of other types, such as videos, or by limited knowledge concerning the types of analytical techniques and their ability to provide useful knowledge.

Figure 2 brings together a detailed and rich list, extracted from our SLR, of SMDA techniques that have been used in providing important Marketing information. Future research can

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combine or apply these techniques separately on different types of data according to their requirements in order to discover new insights.

The most driven marketing strategies by SMDA are Targeting and positioning strategy (78), followed by Communications and influence strategy (23), Product, service, and brand strategy (17), Channel and logistics strategies (5), and Pricing Strategy (1). Our SLR identified, for each type of Strategy, the main Marketing advantages offered by the application of SMDA techniques, obtained from the 120 studied articles (Figure 2). In addition, the content analysis of SLR articles indicates that, unlike the rest of the strategies, the Targeting and positioning strategy takes advantage of TripAdvisor more than Instagram.

We have classified the different techniques used for each type of marketing strategy. Results show that Sentiment Analysis and Artificial Intelligence techniques are the most applied techniques for SMDA to provide knowledge to "Targeting Strategy and Positioning", and "Channel Strategy and Logistics", while Coding and Modelling algorithms are the most adopted by analysts for other types of Strategies (Table 2).

Table 2. Crossing of Marketing Strategies and Methods

		Social Media Data Analytics Methods							
		Sentiment Analysis	Data Mining	Statistics	Coding and Modeling	Visualization	Artificial Intelligence	Simulation	Total (Strategies)
Marketing Strategies	Targeting and positioning strategy	28	22	11	15	3	27	0	78
	Communication and influence strategy	4	3	7	8	0	4	1	23
	Product, service and brand strategy	5	3	2	7	1	4	0	17
	Pricing strategy	0	0	0	1	0	0	0	1
	Channel and logistics strategy	4	2	0	0	1	4	0	5
Total (Methods)		38	29	19	30	5	37	1	120

The results illustrated in Table 3 demonstrate that to extract knowledge for Marketing Strategies, Sentiment Analysis is most applied in the following fields: "Agri-business and food industry", "Transport, air transport and airport", "Commerce and trade", "Automotive industry", "Media, Marketing and Advertising Services", and "Technology". Data Mining is also widely used in the sectors of "Commerce and trade", "Education and Culture", and "Tourism, Destinations, Hotels, and restaurants".

In addition, Coding and Modelling ranks first in the following fields: "Banking, Financial Sector and Insurance", "Education and Culture", "Politics and government", and "Media,

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Marketing and Advertising Services". The use of artificial intelligence dominates in these fields: "Education and Culture", "Entrepreneurship, Startups, Employability and recruitment", "Automotive industry", "Media, Marketing and Advertising Services", "Medicine, health and pharmacy", and "Clothing, Fashion and Beauty".

Table 3. Crossing of Fields and Methods

		SOCIAL MEDIA DATA ANALYTICS METHODS							
		Sentiment Analysis	Data Mining	Statistics	Coding and Modeling	Visualization	Artificial Intelligence	Simulation	Total (FIELDS)
FIELDS	Agri business, food industry	7	3	1	5	1	5	0	17
	Banking, Financial Sector and Insurance	2	1	1	4	0	2	0	7
	Commerce, trade	5	5	1	3	1	4	0	12
	Transport, air transport and airport	4	3	0	2	2	2	0	8
	Education and culture	1	3	1	3	0	3	0	8
	Entrepreneurship, Startups, Employability and recruitment	1	0	1	0	0	2	0	2
	Tourism, Hotels, and restaurants	5	8	7	6	1	5	0	25
	Automotive industry	4	2	0	3	1	4	0	8
	Media, Marketing and Advertising Services	8	2	3	8	2	8	0	23
	Medicine, health and pharmacy	0	1	0	0	0	2	0	3
	Politics, government	2	2	1	8	0	2	0	13
	Technology	12	3	0	2	2	9	1	18
	Clothing, Fashion and Beauty	2	1	2	1	1	5	0	8
	Others (Real Estate 1+ Bioenergy)	1	0	0	1	0	0	0	2
Total (METHODS)		38	29	18	30	5	37	1	119

Finally, the results show that the use of several analytical methods and techniques in many fields is still very poor, maybe not used at all, like Visualization in the field of "Banking, Financial Sector and Insurance", and Statistics in the field of "Technology" (Table 3).

To provide an overview of the SMDA process for marketing strategies, Figure 2 proposes an integrative framework mapping these research findings about how SMDA create value to marketing strategies including methods and techniques. Figure 2 also shows, in a global way, the steps of SMDA starting with Social Media platforms going to the marketing decisions and advantages obtained thanks to SMDA.

The global view of the studied process makes it possible to understand, in a simple way, the contribution of our SLR and facilitates the observation of several important results.

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For example, by taking a look at Figure 2, we can quickly notice that Targeting and Positioning Strategies are the most guided strategies by SMDA compared to the strategies of the marketing mix elements. The same remark goes for SMDA methods. It is clear that some methods are negligible in terms of their use compared to others, such as Simulation Vs Artificial Intelligence.

Conclusion, Implications and Perspectives

This study aims to provide a useful piece of research on the use of SMDA in future marketing studies. Through a systematic review and a comprehensive view of the key aspects of SMDA, this paper encapsulates the majority of analytical techniques to support all types of marketing decisions. In addition, this study expresses that, once SMDA techniques, Data types, and platforms are chosen effectively; and challenges are well defined, the use of SMDA will maximize Marketing Strategies' value. The results of the SLR answered our research questions by providing a wide selection of effective SMDA techniques, as well as a detailed list of the Marketing Strategies' benefits provided by these techniques.

The implications of this study are that practitioners and researchers can quickly choose, according to their Marketing objectives, the suitable Social Media platform, the most correct type of data, and the most appropriate analysis technique. Another contribution is that this research represents a map that can inspire and guide researchers seeking to know the most used analysis techniques and understand what Marketing Strategies these techniques could guide. Therefore, this study generates knowledge in the area of SMDA and Marketing Strategies and provides directions for future researchers. Indeed, this study suggests that future researchers conduct more empirical and systematic studies on the SMDA and Marketing Strategies to explore more insights that may support a company to amplify the adoption of SMDA for the improvement of Marketing Strategies.

The results of this study show that the rate of use of SMDA for the benefit of pricing strategies, channel and logistics strategies is very low. Then, more studies on these topics should be conducted. In addition, the SMDA is poorly used by SMEs. Future studies could focus more on the factors that may assist SMEs to adopt SMDA. Moreover, the classification according to the fields indicates that a concern with SMDA for Marketing Strategies has been lacking in several critical areas, such as Bioenergy, Entrepreneurship, Start-ups, and Medicine and pharmacy. That result may encourage companies and researchers in these fields to take an interest in SMDA for marketing decisions.

Finally, the content analysis of articles in this SLR was carried out manually; thus, future research may use automatic analysis of articles through analysis software to make it possible

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to process a greater number of papers and foster larger SLRs to shed more light on the role of SMDA for Marketing Strategies.

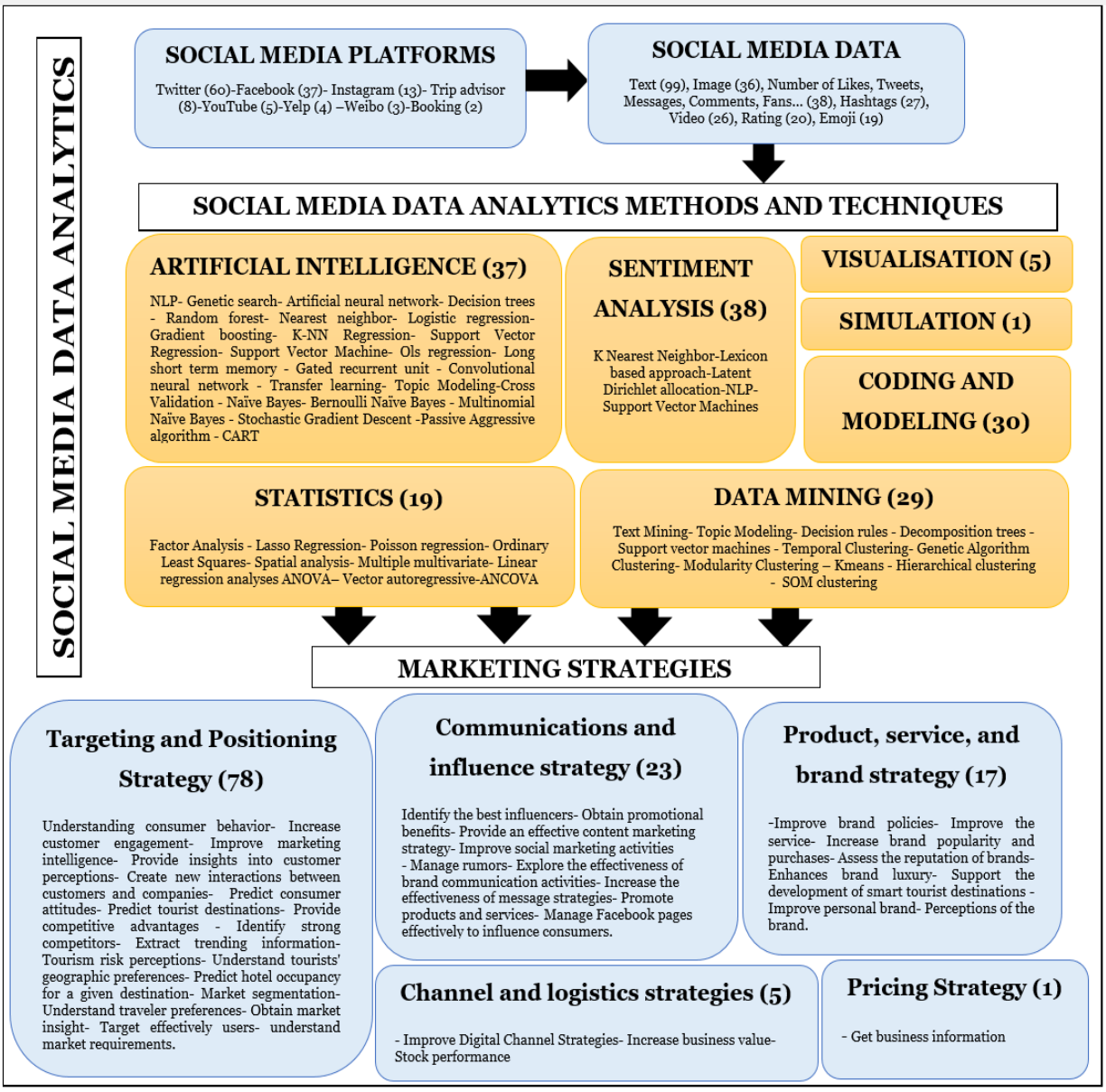

Figure 2. Social Media Data Analytics for Marketing Strategies: Theoretical Framework

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Measuring E-Browsing Behaviour and Testing its Impact on Online Immersion

Salma Ayari
E.S.C., La Manouba University, Tunisia

Imène Ben Yahia
ESC, La Manouba University

Mohsen Debabi
IHEC, University of Carthage

Abstract: In an online environment, enriched by different types of cues that may distract a consumer, investigating and operationalizing, e-browsing behaviour becomes a must to understand consumer behaviour online. Nevertheless, existing research on the online environment has only used and adapted scales measuring offline browsing. In fact, the existing literature fails to offer a scale measuring browsing specifically in the online context. Consequently, this study fills this gap by developing a scale measuring e-browsing following the Churchill paradigm enriched with the recommendations of Rossiter. For this purpose, a number of methodological instruments are used: two focus groups (the first with 4 experts and the second with 18 consumers) and three surveys (140 students for the first survey, 350 and 200 Internet users, respectively, for the second and third survey). Results put forth a unidimensional scale with 7 items, which seems to exhibit evidence of reliability and validity. The predictive validity was checked by testing the impact of e-browsing on online immersion. The proposed scale measure may help academicians perform better and more reliable studies on consumer behaviour online. It may help managers better understand the traffic on their websites and segment visitors to tailor better conversion strategies.

Keywords: Measurement scale development, e-browsing, online behaviour, merchant website consumer behaviour

Introduction

Increasing website traffic is a fundamental pillar for making online purchases (Laroutis, Boistel & Badot, 2021; Kim & Pant, 2019; Zheng *et al.*, 2019), especially given that merchant websites are not only a place where Internet users buy their products but also a place for social life, discovery, walks and relaxation (Kim & Pant, 2019). However, the percentage at a

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given moment of Internet users who are only browsing the website can be significant. Browsing is defined by Bloch & Richins (1983) as “a leisure activity in stores, carried out without intention to purchase, and whose motivations are mainly recreational”. In other words, Internet users can browse certain websites not because they have a particular purchase intention, but because they just want to "browse". Much research has drawn attention to the importance of the browsing behaviour, whether offline or online (Lombard & Labbé, 2015; Liu *et al.*, 2018 ; Ono *et al.*, 2012). For instance, Ho (2021) highlighted that consumers' latent shopping intent and related behaviours within a website depend on channels the consumers click through and, consequently, on the goal-directed and exploratory (browsing) modes.

Bloch, Ridgway & Sherrell (1989) have suggested that browsers could play the role of prescribers for other types of consumers, such as shoppers, and therefore generate sales. Other researchers (Bloch, Ridgway & Sherrell, 1989) mentioned that consumers engaging in a browsing activity would be likely to advertise stores in which they regularly browse, as well as products with which they came into contact during their visits to the sale points. Furthermore, Lombard & Blandine (2015) highlighted the importance of segmenting the consumers based on the intensity of their browsing behaviour and of adapting companies’ communication strategies in order to convert visitors into buyers or to retain them in store. In the same line of reflection, Lu *et al.* (2020) have recommended to differentiate between consumers who are genuinely interested in purchasing a product and those who are randomly visiting product pages. For the second, they discourage links to other product forums or product unrelated content.

Previous research has shown that the online environment presents many stimuli and recreational benefits that may increase search and revisit probabilities leading to an experiential behaviour and e-browsing (Lee, 2020). Understanding it becomes, therefore, of great importance to perform efficient communications campaigns by companies. However, despite its importance and the actual context of enriched websites, there is still limited research operationalizing this concept. Indeed, all scale measures found in the literature review are about browsing offline stores. It is even surprising that recent studies on the online environment are using old scale measures even though the latter present obvious weaknesses when applied in the online environment (Chen, Gupta & Pan, 2019; Zhang *et al.*, 2018). For instance, the first measure of browsing activity inside a store is a single-item measure (Bloch & Richins, 1983; Bloch, Ridgway & Sherrell, 1989). Respondents must answer a single question: "How often do you visit stores just to watch or to get information rather than to make a purchase?" This single-item measure of browsing activity is quite reductive and does not consider recreational motivations. Therefore, it does probably not

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fully capture the complexity of the browsing. The second measure of browsing activity was developed by Jarboe & Daniel (1987). This index of measurement poses problems of validity to the extent that several of its constituent elements do not make it possible to clearly differentiate the browsing. The third measure of browsing inside a store was developed by Bloch, Ridgway & Nelson (1991). Respondents must answer three questions to determine their propensity to browse. The values thus assigned are then aggregated to provide an indication of a consumer's propensity to browse. This measure of browsing activity is still fairly general and could pose problems of understanding. In the same framework of analysis, Lombart (2004) developed a scale to measure browsing in a store including 7 items, but none takes into account the specificities of the web. Yet, some recent studies have used the Lombart (2004) scale to measure e-browsing (Tekiki & Abbess, 2020).

Therefore, in the actual context of enriched websites and high familiarity with the web, there is an urgent need to develop a scale measurement of e-browsing. The proposed scale measure may help academicians perform better and more reliable studies on consumer behaviour online. At a managerial level, it may help managers better understand the traffic on their websites and segment visitors to tailor better conversion strategies.

This paper is structured as follows. The concept of browsing is firstly presented, and the main browsing measures noted in the literature are exposed. Second, a presentation of the context of enriched merchant websites may help understand the necessity to develop a scale specific to the online context. Third, the methodology and results detail the different steps of Churchill's paradigm (1979) and the recommendations of Rossiter (2002) applied to develop the scale measure of e-browsing. Finally, the proposed scale measure is discussed before concluding with the contributions, limitations and future agenda.

Back to the Browsing Concept

Browsing can be thought of as "the examination of products in stores, for recreational or informational purposes, without intention to purchase" (Bloch and Richins, 1983). According to this definition, consumers may be interested in the products or services offered, the ambience of the store, its presentation, and other consumers present in the store, with no intention to purchase (Lombart, 2004; Veg-Sala & Geerts, 2021). The browsing activity, conceptualized as a form of recreational experience, is carried out primarily for itself and not for the possibility of purchase that it offers. Thus, the concept of browsing is different from other adjacent concepts such as shopping, and window shopping. Shopping is "going from store to store to buy". This definition clearly emphasizes that the term “shopping” refers to the purchase of products or services (Jallais, Orsoni & Fady, 1994). So, the intention to buy distinguishes shopping (carried out with intention to buy) from browsing (carried out

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without intention to buy) (Shields, 1992). Ultimately, window shopping is a stimulus-seeking behaviour that can be accomplished with or without an intention to purchase (Jallais, Orsoni & Fady, 1994). This window-shopping activity is mainly conducted by consumers outside the stores (Jallais, Orsoni & Fady, 1994); conversely to browsing, which is a behaviour adopted inside stores. Many authors have considered the behaviour of browsing and have proposed a measure scale for it. Table 1 exposes some of the measurements and presents their limitations when applied online (Table 1).

Table1. Measurement scale of browsing

Authors	Objective	Scale measuring browsing	Limitations
Bloch & Richins, (1983); Bloch, Ridgway & Sherrell, (1989)	Measure the activity of browsing inside a store	-A single question. -By means of a 5-point scale ranging from "never" to “very often”	It does not consider recreational motivations. Therefore, it probably does not fully capture the complexity of the construct that is browsing.
Jarboe & McDaniel (1987)	Measure the activity of browsing inside a store	First, the respondents must answer dichotomously to the question: "Are you a browser (browser)?" Secondly, they must complete an index composed of 5 items. Respondents have the choice between the modalities of the following responses: “never; sometimes; always".	This index for measuring browsing activity poses validity issues, as several of its constituent elements do not allow to differentiate clearly browsing shopping.
Bloch, Ridgway & Nelson (1991)	Measure the activity of browsing inside a store	The respondents must answer three open-ended questions in order to determine their propensity to forage	This measurement of browsing activity is general and poses problems of understanding.
Lombart (2004)	Measure the activity of browsing inside a store	Churchill paradigm	This scale does not take into account the specificities of the web.

Browsing in the Online Context

Since the work of Donna and Novak (1997), several researchers (Novak, Hoffman & Yung, 2000; Donna & Novak, 1997 ; Hausman & Siekpe, 2009; Hsu, Chang & Chen, 2012) have studied online consumer behaviour, in particular their experience of shopping and browsing. Thus, the development of technologies allows the user to perform a task virtually while having the impression of performing it in the real world (Arnaldi, Guitton & Moreau, 2018). The advent of merchant sites on the Internet has radically changed consumer behaviour. It does not necessarily seek to accomplish a task within a commercial website. The consumer prefers to live an experience full of different emotions. In the same way, the contemporary

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consumer prefers to live consumption experiences rather than to buy simple products or services (Carù & Cova, 2006).

For, Zhang *et al.* (2018), browsing positively affects consumers' urge to buy impulsively and finally affects their impulse buying behaviour. They used the measurement scale of Floh & Madlberger (2013) of e-browsing, with two items about the percentage of time spent just looking around on the online group shopping website, and the intent to just look around on the online group shopping website. This scale does not describe the real behaviour of browsing. Similarly, Rezaei *et al.* (2016) have found that browsing may enhance online impulse buying. Chen, Gupta & Pan (2019) have shown that e-browsing enhances customers' urge to buy impulsively and continuance intention. Both studies used Park *et al.* (2012) scale measure, which was adapted from the twelve items of Babin, Darden & Griffin (1994). Ono *et al.* (2012) have examined the effects of consumer motivations on browsing online stores with mobile devices and compared them with those on browsing physical stores. Results showed that adventure motivation are important for mobile-based online stores, whereas gratification motivation is important for physical stores.

Researchers like Xu-Priour, Truong & Klink (2014) studied the effect of online social interaction on the e-browsing experience between two different cultures (Chinese and French). Thus, they stipulated that e-browsing experience and trust perception are positively related to behavioural intention to use. It is worth noting that the authors have used the Bloch & Richins (1983) scale in their research. Kaufman & Lindquist (2002) have defined an e-browser as: "someone who browses retail Websites but makes no purchase". They have added that persons who report online browsing without online purchasing will indicate a higher preference for in-store purchase than those who browse and purchase online. Law & Hsu (2006) have examined two groups of users (online browsers and online purchasers) of international hotel websites on their perceived importance level of specific dimensions and attributes on hotel websites. They stipulated that e-browsers are Internet users who had visited any hotel website in the past 12 months and did not make any purchase. Park *et al.* (2012) have examined the relationship among product attributes, web browsing, and impulse buying for apparel products in the Internet context. They used twelve items adapted from the literature measure of web browsing of Babin, Darden & Griffin (1994) and Lee & Lee (2003).

Other researchers have proposed typologies of e-consumers based on the purpose of their presence online and have identified consequently e-browsers. For instance, Econsultancy (2005) distinguished between trackers, hunters and explorers. The latter do not have any particular type of product in mind. They may have well defined shopping objectives (e.g., a

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present for a significant other) or even not at all. Cova & Cova (2004) distinguished two navigation behaviours, one directed towards a goal and the other exploratory. Indeed, according to them, the consumer experience is not limited to pre-purchase activities (awakening of needs, search for information, etc.), nor to post-purchase activities (evaluation and satisfaction), but encompasses a series of other activities (pleasure, curiosity) to influence the consumer's future decisions and actions. In the same framework of analysis, Novak, Hoffman & Yung (2000) showed that exploratory behaviour is related to an experience (search by simple curiosity). In the same way, Wolfinbarger & Gilly (2001) segment Internet users according to the purpose of their navigation and to the importance of the hedonic dimension of users' surfing. They distinguished goal-directed behaviour from experiential behaviour. The first is a structured behaviour to achieve specific goals, which are established beforehand. The user navigation is structured and linear because it is directed towards a specific goal. It is characterized by commercial or functional benefits corresponding to the objectives of the visit to the website, such as collecting information on the brand or its products, getting samples, discounts or buying online. The second, which is the experiential behaviour, is "unstructured" and corresponds more to lingering on a site, an activity that can possibly be achieved by a purchase which was not initially decided: e-browsing the website of a luxury brand for aesthetic pleasure of immerging in its world, to dream, to discover the new collections, events and history. It is characterized by hedonic or experiential benefits. They concern hedonic, aesthetic and symbolic aspects of the visitor experience. They correspond to the subjective responses of the user to different sensory stimuli and include emotional reactions. Wolfinbarger & Gilly (2001) highlight that these types of behaviours influence the assessment of the offer and are strongly influenced by situational and individual variables. That is, in the case of a goal-directed behaviour, the consumer will assess the commercial offer by comparing all the offers available. Therefore, variable prices on the Internet can be a determining factor in the purchase of some product categories due to the transparency and the visibility offered by this channel. For experiential behaviour, the goals of the user are progressively set while navigating (Donna & Novak, 1997). In this case, the attention and the perception of the user are oriented towards sensations, emotional reactions and mental evocations. Atmospheric factors may influence the visitor experience. This mode of behaviour induces an overall assessment.

Research Method

To develop the measurement scale of e-browsing, the Churchill paradigm (1979) enriched with Rossiter (2002) is applied in this research through the five steps detailed in Table 2.

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Table 2. Application of Churchill's paradigm (1979)

Steps	Studies
1st step: Specify the domain of the construct	• Definition of the concept of online browsing • Qualitative study: 18 consumers questioned about their browsing behaviour (semi-structured individual interviews)
2nd step: Generate a sample of statements	• Drafting of 11 items • Submission to 4 experts • This leads to the deletion of two items
3rd step: First data collection	• Data collection: 140 consumers asked about their browsing behaviour • Selection of a 5-point Likert format • Exploratory factor analysis (analysis principal component factorial). • This leads to the deletion of two items
4th step: second data collection	• Data collection: 350 consumers asked about their browsing behaviour • Selection of a 5-point Likert format • Exploratory factor analysis (analysis principal component factorial). • The number of items kept is 7
5th step: Purification phase	• Confirmatory factor analysis: PLS 3 • Evaluation of convergent and discriminating validity based on responses from 350 consumers • Testing predictive validity: the effect of online immersion on e-browsing (200 consumers)

Specifying the domain of the construct and generating statements: Based on the literature review, the definition of Bloch & Richins (1983) is retained. However, to adapt it to the context of websites, we adapt it as follows: “the examination of the offer online, for recreational or informational purposes, without intention to purchase"**.** To better understand the concept of e-browsing, a qualitative study was conducted. It was also used to generate items for the measurement scale. Eighteen in-depth interviews were carried out (nine men and nine women, between 25 and 44 years old; belonging to various socio-professional categories, having various levels of qualification and coming from different sectors of activities).

Interviewees were first asked to browse the matterport.com website: https://matterport.com/3d-marketing-for-real-estate/. Second, they were asked to describe their experience with the website in terms of what they liked and disliked and to think about their intention to buy and to revisit it. Lastly, interviewees were asked to share their motives to revisit the website again. Findings from the interviews confirm the relevance of the e-browsing behaviour. Indeed, some interviewees intend to revisit the website as a form of leisure to enjoy the site design, virtual reality. For instance: "*I have really liked the conception of this website, the visit ... the design ... I will come back to visit the site for an extraordinary experience*".

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Table3. Profile of Respondents

Individual	Gender	Age	Socio-Professional Category	Length of interview
1	M	32	Mechanical engineer	30 minutes
2	M	43	Lawyer	25 minutes
3	W	25	Student	40 minutes
4	M	35	Chief Service	25 minutes
5	W	26	Student	30 minutes
6	W	28	PhD student	20 minutes
7	W	30	Unemployed	30 minutes
8	M	40	Dentist	37 minutes
9	W	43	Trader	35 minutes
10	W	40	Paediatrician	25 minutes
11	W	27	PhD student	40 minutes
12	M	37	Accountant	30 minutes
13	M	30	IT engineer	35 minutes
14	M	36	Teacher	25 minutes
15	W	26	PhD student	35 minutes
16	M	39	Teacher	30 minutes
17	W	44	Commercial Director	35 minutes
18	M	38	Production manager	40 minutes

Following the recommendations of Rossiter (2002), several items were formulated. Afterwards, a qualitative pretest was conducted by submitting the statements to four experts. The experts gave their opinion on the clarity of the proposals. Two proposals were deleted as they were deemed too redundant or not applicable to our construct. Some proposals have also been reformulated. Finally, nine items were retained. At this step, we can thus propose a definition of online browsing: "*an online experience lived by the consumer, full of different emotions, following an experiential consumption of products in a virtual store, without intention to purchase*".

***Exploratory analysis*:** In order to pretest the items, data was collected from 140 Internet users. To ensure the reliability of the data collection, a website, likely to foster e-browsing was chosen (https://www.darellamma.com/darellamma). Under laboratory conditions, Tunisian business students were invited to visit the website, which offers guesthouse stays, for 15 minutes. Upon completion, participants were given a questionnaire composed of the items generated previously and asked to rate the items on a 5-point Likert scale ranging from 1 ("Strongly disagree") to 5 ("Totally agree"). Principal component analysis was undertaken. The various statistical analyzes carried out revealed a single dimension made up of the items. This factor explains 60.736% of the total variance. Cronbach's alpha (standardized) is 0.878. All the items except two have a satisfactory quality of representation or commonality, that is to say, greater than 0.50. (See Table 4.) However, the last two items of the qualitative study have been deleted. Therefore, seven items are retained.

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Table 4. Factor analysis and reliability test results

Item	Quality of representation	Factor loading
- Strolling through some merchant websites is a real pleasure for me.	0.702	0.865
-Sometimes I wander through online shopping websites the way other people go to a movie or a soccer game, just to relax.	0.690	0.830
-It happens very often that I browse certain merchant websites, purely for pleasure, without intending to buy anything.	0.688	0.825
-It is part of my leisure time to spend time in certain merchant websites to stroll around, without buying anything there.	0.650	0.802
-I consider that browsing a merchant website, without any purchase purpose, just to spend a moment there, is a waste of time.	0.616	0.764
-I consider that strolling in certain sites, without buying anything there, is a real hobby.	0.590	0.760
-It happens very often that I browse certain websites first for fun and then, possibly, to inform myself.	0.560	0.680
-I really liked the concept of this site, I will come back to visit the site for the pleasure.	0.411	0.404
-I'm just discovering the site.	0.402	0.401
Eigenvalue % of variance explained Cronbach's alpha (standardized) Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy	5.668 60.736 0.878 0.802	

***Test and confirmatory analysis of the scale*:** The previous purification was carried out on students under laboratory conditions. In this phase, the objective is to verify the psychometric quality of the scale on a heterogeneous population of Internet users and in conditions outside the laboratory. In line with previous research on consumer online behaviour (Barbot & Kaufman, 2020; Charfi & Volle, 2011), participants were invited to browse the website for 10 minutes and answer a questionnaire made up of 7 post-purification items. A pool of 360 questionnaires was collected. However, some of them were eliminated because participants were familiar with the website (a filter question was included for this purpose). Thus, 350 questionnaires were retained; 52% of the respondents were women and 48% men. A majority of these respondents have a university diploma and they belong to different socio-economic categories. It should be noted that the results obtained during this second phase corroborate those obtained during phase 1 in two major aspects.

Carrying out the Principal Component Analysis (PCA) requires checking the factorization conditions of the browsing measurement scale. All values are above the critical threshold of 0.5. A PCA was performed on the seven items of the measurement scale. The Kaiser Mayer

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Olkin criterion was equal to 0.812 and leads to retention of a single factor explaining 74.78% of the variance. All factor contributions varied between 0.512 and 0.840. Consequently, all the items of this measurement scale have been kept. Cronbach's alpha was equal to 0.886 demonstrating a good reliability of the scale. The results are presented in Table 5.

Table 5. Purification test of the online browsing variable

Item	Quality of representation	Factor loading
1-It happens very often that I browse certain merchant websites, purely for pleasure, without intending to buy anything.	0.840	0.916
2-Strolling through some merchant websites is a real pleasure for me.	0.822	0.910
3- I consider that browsing a merchant website, without any purchase purpose, just to spend a moment there, is a waste of time.	0.818	0.904
4- Sometimes I wander through online shopping websites the way other people go to a movie or a soccer game, just to relax.	0.688	0.824
5- It is part of my leisure to spend time in certain merchant websites to surf around, without buying anything.	0.650	0.802
6- I consider that strolling in certain websites, without buying anything there, is a real hobby	0.590	0.680
7- It happens very often that I browse certain websites first for fun and then, possibly, to inform myself.	0.512	0.616
Eigenvalue % of variance explained Cronbach's alpha (standardized) KMO	5.996 74.789% 0.886 0.812	

A confirmatory factor analysis (CFA) was then conducted using Smart PLS3 on the entire sample (350 respondents) to check the convergent, discriminant and predictive validity. The composite reliability index obtained was 0.949 and the AVE (shared mean variance) was 0.860, which exceeds the required threshold of 0.7 (Chin, Peterson & Brown, 2008). Consequently, convergent validity is ensured. The discriminant validity is assessed by examining the factorial contributions (loadings) of the items to the construct. We checked, in particular, if, for each construct, the factor contributions are greater than the cross-factor contributions between each item and the other constructs. With reference to the literature, browsing has been shown by several researchers (Lombart & Labbé, 2008; Monglo, 2016) to be a response to a determining factor in Internet user reactions, such as online immersion. To do this, online immersion was measured using the scale of Fornerino, Helme-Guizon & Gotteland (2008). This scale was shown to use excellent psychometric qualities. Two hundred Internet users were selected (part of the 350 consumers questioned during the second data collection). The results show that the online immersion of Internet users has a positive influence on e-browsing ($t > 1.96$; $p < 0.05$. Consequently, the predictive validity is

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ensured. Furthermore, the square root of the AVE for each construct exceeds the inter-construct correlations concerning it. Therefore, the discriminant validity is also assured according to Fornell & Larker (1981).

Table6. Convergent validity criteria

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Browsing online	0.919	0.902	0.949	0.860

Table 7. Result of the research model

Correlation relationship	Correlation coefficients (standardized)	T-statistic	P value
Online immersion -> Browsing online	0.384	4.108	0.000

Table 8. Predictive validity

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistic (|O/STDEV|)	P Value
Online immersion -> Browsing online	0.384	0.382	0.093	4.108	0.000

	R Squared	R Squared Adjusted
Browsing online	0.732	0.721

Conclusions

Previous research has largely studied the behaviour of Internet users (Goel, Hofman & Sirer, 2012; Brown, Pope & Voges, 2003; Kumar *et al.*, 2010). Nevertheless, a measurement scale of online browsing taking into account the specificities of the web was missing.

This research fills in this gap by developing a scale measuring e-browsing behaviour. Results put forth a scale comprising a single factor materialized by 7 statements. The reliability and validity of the scale are satisfactory. In accordance with previous research, this scale is also unidimensional. Furthermore, to test the predictive validity, this research demonstrates that e-browsing influences immersion. This result is in line with Mackenzie (2013), who showed that browsers may have a greater preference for more hedonic site features that facilitate online exploration.

From a managerial point of view, it could be crucial for a manager of a merchant website to have consumers engaging in e-browsing activity, insofar as these surfers would be likely to

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advertise the website as well as the products with which they came into contact during their visit for free.

However, we believe that the limits of our study may open up new avenues of research. The most important to highlight is related to administering the scale to other samples and other classes of commercial websites to ensure its psychometric quality. Indeed, our empirical tests are carried out exclusively on a sample of Tunisian Internet users, who are not necessarily representative of global Internet users. Still, the chosen Internet users were only surveyed on two commercial websites, which may not definitely endorse the quality of the scale developed. Finally, developing a valid and reliable measurement scale is a long and continuous process. Accordingly, we recommend the use of this measurement scale for future browsing-based online research to further test its validity. Further research is needed to overcome these limits.

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Measuring Overall Customer Experience in a Hospitality Collaborative Consumption Context

Evidence from Airbnb Users

Marta Mas Machuca
Universitat Internacional de Catalunya, Department of Economy and Business Organization, Barcelona, Spain

Soumaya Cheikhrouhou
École de gestion, Université de Sherbrooke, Department of Marketing, Quebec, Canada

Deny Bélisle
École de gestion, Université de Sherbrooke, Department of Marketing, Quebec, Canada

Frederic Marimon
Universitat Internacional de Catalunya, Department of Economy and Business Organization, Barcelona, Spain

Abstract: Measuring and managing customer experience is increasingly becoming a priority in the experience-laden hospitality context. With the growing desire of consumers for living more authentic experiences, the collaborative consumption (CC) model has gained significant popularity in this industry. However, to date, the underlying structure of customer experience in a hospitality CC context has not been uncovered and a generalizable quantitative measure is yet to be developed. To fill this gap, this research aims to develop and validate a scale for measuring customer experience in a hospitality CC context. Based on a sample collected from Airbnb customers, results yield a 17-item five-dimensional scale (Platform brand experience, Accommodation sensory experience, Social experience with the host, Platform responsive capacity, and Quality of interaction with the host). This work demonstrates that providing an excellent customer experience in a CC context stems from a customer-centred approach from all the involved parties. Theoretical and managerial implications are also presented, along with relevant research avenues.

Keywords: customer experience, collaborative consumption, service quality, platform brand experience, sensory experience.

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Introduction

With the increasing desire of consumers for living more authentic experiences, the conventional business model (Business-to-Consumer, B-to-C) in the hospitality industry is now facing unprecedented competition from the peer-to-peer (P-to-P) accommodation rentals, that companies such as Airbnb, Couchsurfing, and Hospitality Club offer (Camilleri & Neuhofer, 2017). P-to-P transactions are a fundamental part of the sharing economy, also referred to as collaborative consumption (CC) and defined as "peer-to-peer-based activity of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services" (Hamari, Sjöklint & Ukkonen, 2016). In the highly competitive and evolving hospitality industry, providing a superior customer experience has therefore become a central focus for marketers (Forno & Garibaldi, 2015). In parallel, investigating customer experience and its impact on consumers has increasingly interested marketing and hospitality researchers, who have demonstrated the richness and the context-specific nature of this concept (e.g., Schlosser, Mick & Deighton, 2003). In the literature, researchers studied customer experience in a variety of contexts and accordingly developed different constructs, such as product experience (Hoch, 2002), shopping and service experiences (Kerin, Jain & Howard, 1992), and consumption experience (Holbrook & Hirschman, 1982). Most research pertaining to customer experience in a hospitality context focused on the conventional sector and, until recently, very few papers studied it from a CC perspective (Camilleri & Neuhofer, 2017; Lyu, Li & Law, 2019). Besides, most of the literature on customer experience in a CC hospitality context used a qualitative approach, which provided an insightful understanding of the experiential aspects, but did not provide a specific and generalizable measure to assess it (e.g., Camilleri & Neuhofer, 2017; Lyu, Li & Law, 2019). On the other hand, most studies that investigated this phenomenon using a quantitative approach did not focus on its conceptualization and did not specifically adapt their measures to the CC unique characteristics. One main difference with the conventional hospitality context, for instance, lies in the multifaceted nature of the CC service itself, which includes interactions with: 1) the provider platform through which the accommodation is booked; 2) the accommodation itself; and 3) the host with whom customers interact during their stay. This specificity calls for a necessary adaptation of the manner in which researchers and marketers assess customer experience in a multilevel interaction-laden CC context. To fill this void, this paper aims to develop and validate a scale for measuring customer experience in a hospitality CC context (CC-Customer Experience). Its main purpose is twofold: to enhance the understanding of customer experience in a hospitality peer-to-peer context; and to develop a measurement tool that is relevant for both researchers and practitioners.

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Literature Review

Collaborative consumption and customer experience: theoretical foundations

Collaborative consumption (CC), or the sharing economy, is a new paradigm proposed as a more sustainable model of economic organization against the backdrop of energy crises, environmental degradation, and economic recession (Botsman & Rogers, 2011). According to Benoit *et al.* (2017), three types of actors interplay in a CC context: the customer, the host, and the digital platform service provider. This specificity confers three characteristics to CC: (i) the number and types of actors involved (i.e., a triadic relationship); (ii) the nature of the exchange between the three actors (i.e., there is no exchange of ownership in comparison with a traditional exchange model); and (iii) the fact that this relationship is mediated by a market-based mechanism. These characteristics highlight the key importance of comprehending the way customers perceive and experience service delivery in such a context. Specifically, transactions in a hospitality CC environment involve a wide range of touchpoints among these three actors where the customer goes through a virtual exchange with the CC digital platform, mostly face-to-face interactions with the host alone, and an immersion in the accommodation's physical environment. When customers experience a service delivery through the Airbnb platform, for instance, it is the host, who is not an Airbnb employee, who gives access to the accommodation to the guests. Yet, customers still anticipate a high-quality service provision that they expect from the Airbnb brand and they evaluate the platform accordingly. Their overall experience is likely to influence the reputation of the digital platform that consumers use to book, pay, and review the accommodations they stayed at, such as Airbnb. As well, all the CC hospitality industry can therefore be affected by each interaction through the service experience, including the service delivery experienced with a variety of hosts who advertise their accommodations using this platform (Ert, Fleischer & Magen, 2016).

Customer experience "involves the customer's cognitive, affective, emotional, social, and physical response to the entity, product, and service" (Verhoef *et al.*, 2009). It has both utilitarian and hedonic purposes (Schlosser, Mick & Deighton, 2003). While the utilitarian purpose refers to a cognitive, goal-directed, and performance delivery as assessed by service quality evaluation, the hedonic one is characterized by an affective state where the consumer is seeking a fun and enjoyable service experience (Schlosser, Mick & Deighton, 2003). Accordingly, we conceptualize CC customer experience as a global construct comprised of two main dimensions, which are hospitality service experience and service quality. We view the overall customer experience as a multilayered construct that does not only include the customer's evaluation of service quality, but also the more experiential aspects of the service.

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Specifically, service quality captures the evaluation of goal-oriented cognitive aspects of the customer experience, such as the functional and technical aspects of service delivery, while service experience encompasses the assessment of its subjective aspects, such as the hedonic and social content of the customer experience. This conceptualization is in line with the holistic nature of the total customer experience as described and defined by Verhoef *et al.* (2009), which encompasses aspects that the service provider can control (e.g., platform design, accommodations assortment, price), and those that are outside of its control (e.g., interactions and social influence).

Service quality in a collaborative consumption hospitality context

Past research has shown the key role of service quality in a CC hospitality context, as this concept has been directly linked with customer satisfaction and loyalty (e.g., Möhlmann, 2015; Tussyadiah, 2016). Service quality has been defined in the literature as the extent to which a service meets or exceeds customers' expectations (Parasuraman, Zeithaml & Berry, 1998) and was initially measured using Parasuraman, Zeithaml & Berry's (1988) SERVQUAL scale. Former research has demonstrated that the traditional SERVQUAL scale is inadequate in a peer-to-peer context due to the triadic nature of the CC relationships, among other reasons (Marimon *et al.*, 2019). Accordingly, Marimon *et al.* (2019) proposed and validated an adapted scale, named CC-Qual, that is specifically designed to measure the quality of service provided through a CC model. Based on this conceptualization, CC service quality consists of five dimensions, three of which are related to the interaction with the platform and two pertain to the perceived quality of the host. The first dimension of CC-Qual, site organization, assesses how easy it is for customers to find information on the website and how easy it is for them to interact with this platform. The second dimension, platform responsiveness and agility, refers to how the platform provides quick feedback to customers' inquiries and complaints. The third dimension, legal protection and trustworthiness, measures to what extent the platform ensures the protection of customers' personal information and provides a safe environment for customers to conduct online transactions. The fourth dimension, the quality of interaction with the host, assesses the customer-perceived professionalism, competence, trustworthiness, and honesty of the host. Finally, the fifth dimension, social interaction, evaluates the quality of the customer's social interaction with both the other users and with the host. Given its specific development for a service-based CC context, this is the conceptualization of service quality that we adopt in the current paper.

Hospitality service experience in a collaborative consumption context

Among all services, hospitality has been characterized by its promise and delivery of something beyond ordinary to its consumers (Xu & Chan, 2010). Whilst most services typically

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aim to satisfy the functional needs of customers through service quality, hospitality service aims to satisfy their experiential needs too (Xu & Chan, 2010). Otto & Ritchie (1996) showed the importance of adapting service experience measures to the characteristics of the specific service it refers to, a tourism service experience being different from the banking service experience, for instance. In a hospitality CC context, customers often experience more frequent and more intimate service encounters with the service provider than in the conventional hospitality sector. Not only does the peer-to-peer nature of the service add a supplementary actor, which is the host, in the service delivery with whom customers interact, but the typically less formal nature of these interactions is likely to trigger stronger emotional and subjective reactions. These specificities highlight the need to conceptualize service experience in a unique manner in a CC context.

Following the conceptualization of Marimon *et al.* (2019) of a peer-to-peer context, we propose that hospitality service experience in a CC context is built through various touchpoints during the service delivery process: 1) when customers interact with the platform to browse, rent, and review the accommodation, which shapes the platform brand experience; 2) when they interact with the physical environment in the rented accommodation, which leads to the accommodation sensory experience; and 3) when they interact with the host, thus developing the social experience with the host. Accordingly, we propose that CC hospitality service experience is composed of three underlying dimensions: 1) the platform brand experience; 2) the accommodation sensory experience; and 3) the social experience with the host.

Platform brand experience

Brand experience has been defined as "sensations, feelings, cognitions, and behavioural responses evoked by brand-related stimuli that are a part of a brand's design and identity, packaging, communication, and environments" (Brakus, Schmitt & Zarantonello, 2009, p. 52). Four dimensions of brand experience have arisen from Brakus, Schmitt & Zarantonello's (2009) research, which are the sensory, affective, behavioural, and intellectual experience aspects. Nysveen, Pedersen & Skard (2013) added the relational experience to the scale as a fifth dimension of brand experience. In this research, we aim to investigate the platform brand experience, a new conceptualization pertaining to customers' experience with the CC digital platform they are using, such as Airbnb. Including platform brand experience as a component of hospitality service experience in a CC context is coherent with its specific three-way interaction (see Marimon *et al.*, 2019). It is also in line with Ha & Perks' (2005) conceptualization and results with regard to web-based brand experience, which they showed as a key antecedent to satisfaction and brand trust.

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Accommodation sensory experience

The concept of sensory experience has recently emerged as a key concept in the tourism and hospitality literature, where the transformation of consumer experience into something tangible and meaningful is crucial (Ditoiu *et al.*, 2014). In a hospitality context, aspects of the physical environment or the servicescape (Bitner, 1992) have a significant potential to trigger experiential reactions among consumers (Otto & Ritchie, 1996). In a CC hospitality context, the qualitative study undertaken by Lyu and her colleagues (2019) using Airbnb as a setting has demonstrated the importance of sensory experience in a peer-to-peer context, where aspects such as the homelike feeling and warmness of the accommodation were particularly cited by consumers. A satisfying multisensory experience creates a more positive and vivid experience, which will become part of the consumer's long-term memory and have an impact on his/her subsequent behaviour, such as a stronger intention to revisit or to recommend it to others (Agapito, Pinto & Mendes, 2017; Chua *et al.*, 2019, Kim & Perdue, 2013).

Based on Bitner (1992) and Brakus, Schmitt & Zarantonello (2009), we conceptualize sensory experience as the effect of both tangible elements of a physical environment (e.g., atmospherics, physical design and decor elements), which engage customers' senses, and the way they interact with the sensory stimuli of the setting (e.g., the view of the landscape or the taste of local food).

Social experience with the host

Social experience is an important asset in CC contexts where peer-to-peer interactions *per se* have been identified as significant underlying motives for choosing that type of accommodation over the conventional one (Ikkala & Lampinen, 2015). The desire to socialize with new people, to build relationships, and to feel part of a community are social needs that are met through CC and the sharing behaviour it is associated with (Tussyadiah, 2016).

Social experience with the host is conceptualized in this paper as the relationship development with the host and the enjoyment associated with such ties (Ikkala & Lampinen, 2015). It evaluates the host's competence, such as whether he or she is perceived by customers as hospitable, thus interested in the guests staying in the accommodation and concerned that their experience is positive from a social standpoint (Lalicic & Weismayer, 2018). In line with this conceptualization, a hospitable behaviour has been defined as an "authentic desire to entertain and care for the guests and should not be provided to deliberately impress the guest or with the expectation of reward" (Lugosi, 2008).

Based on the literature review and in coherence with Verhoef *et al.*'s (2009) holistic view of experience, we hypothesize that overall CC customer experience in hospitality is composed of two main dimensions: 1) CC hospitality service experience, which includes three

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subdimensions: i) platform brand experience; ii) accommodation sensory experience; and iii) social experience with the host; and 2) CC service quality, which is composed of five subdimensions: i) website organization; ii) platform responsiveness; iii) website legal protection; iv) quality of interaction with the host; and v) quality of social interaction with peers (see Figure 1). Based on this conceptualization, the CC customer experience scale was constructed as described in the following method and results section.

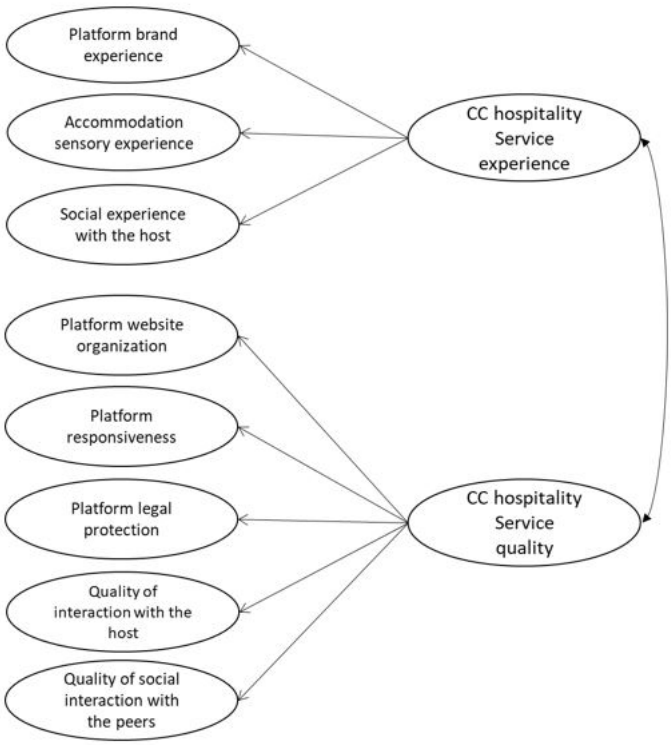

Figure 1. The proposed scale for the CC overall customer experience in hospitality

Method and Results

Construct domain specification

Churchill's (1979) framework for scale development has been adopted. This framework has been widely used in past research, despite being revised and criticized (Rossiter, 2011), particularly in terms of content validity. Given the richness of past literature on the customer experience construct, the original Churchill (1979) scheme will be used in this research. The first step is domain specification where constructs are conceptually defined. Accordingly, Table 1 presents a list of the dimensions included in our preliminary model, their definitions, and the references to past research on which these definitions are based.

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Table 1. Constructs and their dimensions based on past literature

Construct/Dimension		Definition	Sources
Platform brand experience	Brand sensory experience	The way the platform brand (e.g., Airbnb) is perceived by the customer's senses.	Adapted from Brakus, Schmitt & Zarantonello (2009) and Iglesias, Markovic & Rialp (2019).
	Brand affective experience	The customer's perception of the emotions triggered by the platform brand.	
	Brand behavioural experience	The customer's perception of the type of action (active or passive) that the platform brand appeals to. It accounts for bodily experiences and physical actions.	
	Brand intellectual experience	The customer's perception of whether the platform brand encourages its customers to think or take part in an intellectual activity.	
	Brand relational experience	The customer's perception of feelings of belonging to a community thanks to the platform brand.	Adapted from Nysveen, Pedersen & Skard (2013) and Nysveen, Oklevik & Pedersen (2018).
Accommodation sensory experience		The way the accommodation s/he rented is perceived by the customer's senses.	Adapted from Brakus, Schmitt & Zarantonello (2009).
Social experience with the host		The customer's perception of the enjoyment of interacting with the host and the development of social ties with him/her.	Adapted from Smith, Rippe & Dubinsky (2018).
CC service quality	Website organization	The customer's perception of the quality of information organization on the platform's website. It refers to the website's perceived ability to make navigation and transactions easy and intuitive.	Marimon *et al.* (2019)
	Platform responsiveness	The customer's perception of the platform's efficiency, i.e., whether it can respond to customer questions or complaints quickly and satisfactorily.	
	Legal protection	The customer's perception of the platform's safety and adequate handling of personal information.	
	Quality of interaction with the host	The customer's perception of the host's willingness to help and his/her intention to act in the customer's best interest.	
	Social interaction with the peers	The customer's perception of the quality of the social interaction in this P2P context. It assesses the quality of interaction as a whole, including with other customers.	

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Items generation

In this second step, items that best capture the defined domain were generated. Based on the literature review and the constructs definitions, items were collected and grouped to represent each dimension and subdimension of the hypothesized model, thus leading to a first version of the hypothesized scale. The Airbnb platform has been chosen as a setting for this research. While several competing platforms have emerged in the last years, Airbnb is recognised as a pioneer and leader in this industry worldwide, with over 150 million users and 4 million hosts worldwide in 2020 (Bustamante, 2021). Moreover, Airbnb provides an interesting study context not only due to its wide utilization as such by researchers (e.g., Benoit *et al.*, 2017; Ert, Fleischer & Magen, 2016; Tussyadiah 2016), but also to the rich customer experience it aims to deliver, which makes it a very relevant setting for our research that is focusing on the latter.

Scale validation

To validate the proposed scale, a sample of 204 completed questionnaires was collected. The targeted population consisted of Spanish Airbnb customers who have booked a stay using this platform in the last 24 months. The questionnaire consisted of 36 generated items followed by sociodemographic questions. All responses were recorded using a 7-point Likert scale ranging from "completely disagree" to "completely agree". A double back-translation process was applied to the questionnaire to translate the items into Spanish, which was the language in which the survey was carried out. The sample was mostly but not predominantly composed of male consumers (59.80%). Participants were all between 19 and 35 years old, which is in line with the target population of the CC hospitality accommodations. It is also important to note that the vast majority (84.31%) of the respondents rented the full accommodation without sharing it with the host or peer customers. This sample was used both for exploratory purposes and for the final model confirmation analysis.

Exploratory factor analyses

Subdimensions of CC hospitality service experience

Platform brand experience

Platform brand experience (15 items) was analyzed through an exploratory factor analysis (EFA), thorough principal component analysis method. The Kaiser-Meier-Olkin statistic of 0.919 indicated a good result for this analysis. A Barlett test also provided the same conclusion (χ^2 = 3.045 with 435 degrees of freedom and p-value = 0.000). These results confirmed the existence of a linear dependence between the variables. The scale was analyzed using a strict criterion where only items with a factor loading greater than 0.7 were selected and only factors

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with more than one item corresponding to this criterion. Thus, the items selected were intended to be explanatory of the dimension they represent. Only three items, one pertaining to the brand affective experience (BAE1) and two to the brand intellectual experience (BIE1, BIE2) corresponded to these criteria and led to the formation of one platform brand experience factor representing a cumulative total of 56.85% of the variance.

Accommodation sensory experience

The same criteria were applied to the EFA for this construct and all three items were considered representative and corresponded to the criteria. Their loadings ranged between 0.766 and 0.881.

Social experience with the host

In this EFA, out of the three items analyzed, two items exceeded by far the 0.7 loading (0.891 for SEH2 and 0.825 for SEH3), whereas the third (SEH1) was at 0.512. Considering the importance of having three items forming this construct, it was decided to keep the latter as well, even though it did not meet the stricter initial conditions.

Subdimensions of the CC hospitality service quality

The fourth EFA showed that CC hospitality service quality is composed of two dimensions instead of the five originally hypothesized. Four items compose the first subdimension, renamed "Quality of interaction with the host" (26.35% of the variance), while four items represent the second dimension, renamed "Platform response capacity" (18.23% of the variance).

Reliability and confirmatory factor analysis

Based on the EFAs, we propose that the following five subdimensions allow to assess overall CC customer experience in a hospitality context:

- Three subdimensions of CC hospitality service experience:
  i. (PBE) platform brand experience (items BAE1, BIE1, and BIE2);
  ii. (ASE) accommodation sensory experience (items ASE1, ASE2, and ASE3);
  iii. (SEH) social experience with the host (items SEH1, SEH2, and SEH3);
- Two subdimensions of CC hospitality service quality:
  i. (PR) platform response capacity (items PRE1, PRE2, PRE3, and LPR2);
  ii. (QIH) quality of interaction with the host (items SIN2, QIH1, QIH2, and QIH3).

To examine the unidimensionality of the new and definitive five constructs that the initial EFAs yielded, five new independent EFAs were conducted. The five analyses extracted only one factor each. Table 2 shows the statistics for reliability and convergent validity of these five factors. Their high individual items loadings vouched for their reliability. Cronbach's alpha

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coefficient and composite reliability in each case exceeded the threshold value of 0.7, thus confirming their internal consistency (Nunnally & Bernstein, 1994). In addition, the variance extracted for each factor was greater than 0.5, which corresponds to the recommended threshold (Fornell & Larcker, 1981). The Cronbach's alpha values did not improve when any of the items were removed from the scales of each dimension, and the correlations between each item and all the total corrected scales exceeded 0.5. Convergent validity was confirmed for all the analyzed factors and all the items were shown to have significant loadings (t > 2.58).

Table 2. Reliability analysis for the proposed subdimensions

	1		2		3		4		5	
	Platform brand experience		**Accommodation sensory experience**		**Social experience with the host**		**Platform responsiveness**		**Quality of interaction with the host**	
	BAE1	0.837	ASE1	0.801	SEH2	0.891	PRE2	0.775	SIN2	0.827
	BIE1	0.793	ASE3	0.787	SEH3	0.825	PRE3	0.746	QIH1	0.801
	BIE2	0.777	ASE2	0.766	SEH1	0.512	PRE1	0.705	QIH3	0.793
							LPR2	0.699	QIH2	0.730
Cronbach's Alpha	0.815		0.687		0.558		0.793		0.867	
Composite Reliability	0.844		0.828		0.797		0.822		0.868	
Average Variance Extracted	0.644		0.616		0.578		0.536		0.622	

Table 3 presents the results for the discriminant validity analysis, which was conducted using linear correlations or standardized covariances between latent factors by examining whether the inter-factor correlations were less than the square root of the average variance extracted (AVE) (Fornell & Larcker, 1981). As shown in Table 3, the square roots of each AVE were greater than the off-diagonal items, thus demonstrating discriminant validity.

Table 3. Discriminant analysis for the proposed subdimensions

	1	2	3	4	5
1 Platform brand experience	0.803				
2 Accommodation sensory experience	0.346	0.785			
3 Social experience with the host	0.263	0.529	0.761		
4 Platform responsiveness	0.442	0.431	0.448	0.732	
5 Quality of interaction with the host	0.200	0.612	0.821	0.457	0.789

To determine the final scale, the next and last step was to analyze these five subdimensions as dimensions of a second-order CFA, where they were associated with the respective dimensions of the overall CC hospitality customer experience construct, which are CC hospitality service

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experience and CC hospitality service quality (see Figure 2 for the proposed construct structure).

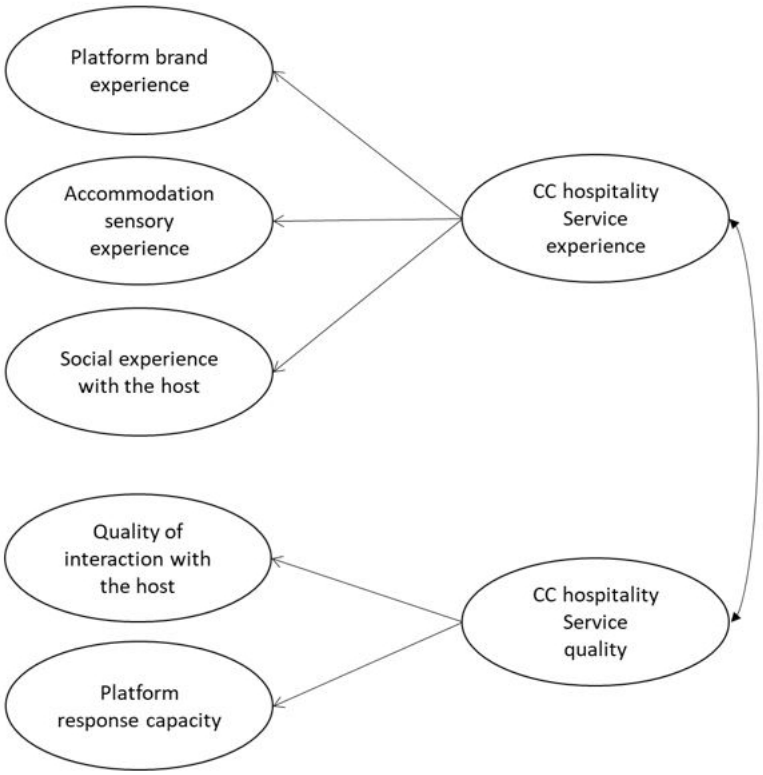

Figure 2. The final validated scale of CC hospitality customer experience

In order to select an appropriate SEM estimation technique, several tests were conducted to assess multivariate and univariate normality. To evaluate multivariate normality, Mardia's coefficient (Mardia, 1970) was calculated, obtaining a normalized estimate value of 22.8, which is a sign of multivariate non-normality (Bentler, 1995). Therefore, the estimation technique applied to the model was the Robust Maximum Likelihood from the asymptotic variance–covariance matrix, the Satorra–Bentler's scaled χ^2 (Satorra & Bentler, 2001) being used as an adjustment to the χ^2 test statistic. The software (EQS) used to conduct the CFA also corrects the extent of non-normality reflected in parameter estimates by adjusting the standard errors (Krishnaiah & Sarkar, 1985).

The outcomes of the Satorra-Bentler test are presented in Table 4, together with other goodness-of-fit parameters that were derived from it. The fit indices showed that the variables converged toward the factors established in the CFA. χ^2 Satorra-Bentler was 219,61, with 113 degrees of freedom and a p-value of 0.000. χ^2/df was 1.943, which was below the acceptable limit of 5, but RMSEA and CFI were 0.068 and 0.900, respectively. Considering the global indicators, the model fit was deemed acceptable. The final scale for CC hospitality overall customer experience is presented in Table 5.

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Table 4. Confirmatory Factor Analysis (CFA) of CC Hospitality Overall Customer Experience

		CFA (sample N=204)		
Dimension	Items	Loading	t-value	r^2
Platform brand experience	BAE1	0.818	4.640	0.576
	BIE1	0.735	6.290	0.679
	BIE2	0.780	5.460	0.625
Accommodation sensory experience	ASE1	0.660	6.320	0.751
	ASE3	0.715	5.220	0.699
	ASE2	0.623	5.539	0.782
Social experience with the host	SEH2	0.312	15.570	0.950
	SEH3	0.873	4.470	0.488
	SEH1	0.614	6.220	0.789
Platform responsiveness	PRE2	0.635	5.530	0.772
	PRE3	0.842	4.410	0.539
	PRE1	0.561	7.720	0.828
	LPR2	0.654	6.950	0.756
Quality of interaction with the host	SIN2	0.835	6.300	0.550
	QIH1	0.602	5.750	0.798
	QIH3	0.842	5.740	0.539
	QIH2	0.859	4.920	0.511
Goodness of fit summary				
Satorra-Bentler scaled χ^2		219.609		
Degrees of freedom		113		
p-value		0.00000		
χ^2/df		1.943		
Comparative fit index (CFI)		0.900		
Root mean-square error of approximation (RMSEA)		0.068		
90% confidence interval of RMSEA		(0.055; 0.081)		

Table 5. The validated scale for CC hospitality customer experience

Subdimension	Item #	Code	Item
Platform brand experience	1	BAE1	Airbnb induces feelings and sentiments in me.
	2	BIE1	I engage in a lot of thinking when I encounter the Airbnb brand.
	3	BIE2	Airbnb makes me think.
Accommodation sensory experience	4	ASE1	This accommodation made a strong impression on my visual sense or other senses.
	6	ASE2	I found this accommodation interesting in a sensory way.
	5	ASE3	This accommodation appealed to my senses.
Social experience with the host	7	SEH1	I spoke to the host about things other than my stay.
	8	SEH2	I have developed a relationship with my host.
	9	SEH3	I enjoyed talking to my host.
Platform responsive capacity	10	PRE1	Airbnb website makes it easy for me to conclude my transaction.
	11	PRE2	The information of the Airbnb website is well organized.
	12	PRE3	Airbnb website is easy to use.
	13	LPR2	I feel assured that legal structures adequately protect me from problems on Airbnb.
Quality of interaction with the host	14	SIN2	The experience helps me interact with the accommodation host.
	15	QIH1	The accommodation host is willing to help customers.

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Subdimension	Item #	Code	Item
	16	QIH2	The accommodation host acts in the customer's best interest.
	17	QIH3	The accommodation host does their best to help.

Finally, nomological and predictive validity was tested by conducting additional models that include two dependent variables, which are "Loyalty" and "Satisfaction". Although the goodness of fit for the expanded model is just below the acceptable threshold, the results show that the CC hospitality customer experience impacts significantly on these constructs, in the same sense that the literature suggests, thus vouching for predictive validity.

Conclusions

Discussion

This research led to the development of a scale measuring customer experience in a hospitality CC context. As hypothesized, this scale encompasses two main dimensions, which are CC service experience and service quality. As expected, the first dimension, CC service experience, includes three subdimensions, which are platform brand experience, accommodation sensory experience, and social experience with the host. On the other hand, the second dimension, CC service quality, appears to be composed of two subdimensions, which are platform responsiveness and the quality of interaction with the host.

The final measures of both accommodation sensory experience and social experience with the host, two subdimensions of CC service experience, included the initial three items used to assess them. However, only items pertaining to affective and intellectual brand experiences were found to represent its third subdimension, platform brand experience. In past research, brand experience has been typically investigated in a product and service brand setting (e.g., Nysveen, Pedersen & Skard, 2013; Zarantonello & Schmitt, 2010) rather than for an online platform, which is less associated with bodily experiences and physical behaviour, and less prone to providing sensory stimulation than a physical retail or service environment. On the other hand, the importance of the affective and intellectual aspects of the experience associated with the platform highlight the necessity of accounting for both the feelings and thinking a CC platform provoke among its users. When building their brand experience, CC platforms managers and strategists need to assess and put forward the platform aspects that favour not only positive feelings and sentiments, but also intellectual stimulation. They might consider, for instance, providing more information about the town and country where the accommodations are located or offer tools allowing for comparing the characteristics of different accommodations, so as to create a stimulating environment that enriches the CC

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platform brand experience and allows it to differentiate itself from competing options, based on the aspects that their customers value most.

Besides, it appears that the sensory experience provided during the stay, as captured by the accommodation sensory experience subdimension, is more strongly imprinted in customers' minds and incorporated in their evaluation of the experience, rather than the sensory information they obtained through their interaction with the platform. This result might seem surprising, given the focus of Airbnb on the quality of the photos displayed on its website and the rich description typically provided by the peers who rent their accommodation through this platform (Ert, Fleischer & Magen, 2016). It is likely that the more vivid and multifaceted sensory stimulation that customers experience during their stay supplants the sensory experience associated with their navigation in the platform and their sensory assessment of the accommodation through it. Future research is needed to understand the phenomenon at play.

Similarly, based on our results, customers seem to perceive that relational experience is not of importance to develop with the platform, while relational and social ties are deemed essential when interacting with the host. In coherence with Ikkala & Lampinen's (2015) findings about the role of social interaction as a source of motivation for the hosts to monetize network hospitality, customers too appear to value social and relational ties in their assessment of CC customer experience.

For the second dimension, which is CC service quality, only two subdimensions were extracted. The first subdimension, social interaction, referred to the quality of a customer's social interaction with other customers and with the host. It represents a cognitive assessment of the interactions with both the host and with other customers, thus highlighting the value associated with the sense of community in the CC experience, in line with Möhlmann's (2015) and Marimon, Mas-Machuca & Llach's (2020) findings about of the role of community belonging in the formation of satisfaction in such a context. The second subdimension, platform responsiveness, refers to the service delivery platform's rapidity and the quality of the reaction of the website to customer's inquiries and complaints (Marimon *et al.*, 2019). These two subdimensions covered key aspects related to the quality of the interaction with the platform, the host, and other consumers, which reflects the multifaceted nature of CC and assesses them from different angles.

Theoretical implications

From a theoretical standpoint, this research contributes to the literature on collaborative consumption, interaction with the platform, and customer experience. It sheds a new light on customer experience, a concept mostly studied using qualitative approaches in CC hospitality

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research (e.g., Camilleri & Neuhofer, 2017; Lyu, Li & Law, 2019), by providing a specific and generalizable measure to assess it. The development of this scale was particularly important, given the lack of focus on conceptualization and the absence of adaptation of this construct to the CC specificities. Our scale provided a novel and insightful understanding of the experiential aspects of CC, while accounting for the multifaceted nature of the delivered service in hospitality, which includes interactions with the provider platform, the accommodation, and the host. By adapting this construct conceptualization and measure to the P-to-P context, this research aims to bring a new way for researchers and marketers to understand and evaluate customer experience in a context where it can stem from three different sources, two of them being less controllable by the service provider who owns and manages the platform. This perspective is in line with the adaptation of the service quality measure that led Marimon *et al.* (2019) to develop their CC-qual scale (i.e., the CC service quality scale).

The current research reveals how consumers view experience in a hospitality CC context. Our results are in line with Ribeiro and Prayag's (2019) and Walter and his colleagues' (2010) view of customer service experience in hospitality as a result of the social interaction, the physical environment, and the core service. These facets have been identified as key indicators of CC-customer experience in our research. First, two aspects of social interactions have been found to be integral components of each dimension of hospitality CC-customer experience in our scale, which are social experience and the quality of interaction with the host. Second, the accommodation sensory experience reflects the customer's evaluation of the physical environment. Third, the assessment of the core service is captured through platform responsiveness, which evaluates various elements related to the service, such as complaint handling, and platform brand experience, which refers to the way the customer feels and thinks about the platform brand.

Managerial implications

From a managerial point of view, this research provides a useful tool for marketers in CC hospitality platforms who allow for measuring and monitoring their customers' experiences. As competition from both the conventional and the shared economy sectors is becoming fiercer than ever, deploying a targeted strategy to enhance customer experience is an increasingly shared view in the industry. Airbnb, for instance, disrupted the conventional hospitality industry by positioning itself as a provider of radically innovative customer experience. From hiring customer experience specialists to collaborating with a leading animation company such as Pixar to create story boards that depict their customers' journey

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(Blust, 2019), Airbnb is capitalizing on customer experience and deploying a wide array of actions to keep all their employees focused on it as a common goal.

This research shows the specific aspects on which CC hospitality platforms need to focus if they aim to deliver a better customer experience, such as capitalizing on the affective and intellectual aspects to offer a valued platform brand experience. This work also demonstrates that providing an excellent customer experience in a CC context stems from effective teamwork and a customer-centred approach from all the involved parties. A better CC hospitality customer experience does not only arise from good service quality delivered by the platform and an effective platform brand experience. It also significantly arises from customers' enjoyment of their social experience with the host and their appreciation of the sensory experience at the accommodation. CC hospitality platforms, such as Airbnb, should not ignore these effects and must be aware of the potential detrimental effect of a bad selection of the advertised accommodation and hosts. While the current practice of offering "super host" badges is a good step toward an adequate accounting for these aspects, a specific partnership strategy with the hosts aiming to provide the best customer experience needs to be developed. Various incentives, such as priority display in searches, or additional types of badges highlighting specific aspects of the expected experience with the host, can accordingly be implemented. Besides, the inclusion of specific questions about the sensory evaluation of the accommodation and the relationship ties with the host in the usual post-stay customer evaluation survey must serve as a guideline to categorize the accommodation, given their importance in CC customer experience. Including descriptions of not only the visual, but also the auditory (quiet), olfactory (apartment and neighbourhood good smell), and gustatory (e.g., food gift basket) aspects of the accommodation need to be put forward in their descriptions on the platform in order to form realistic expectations regarding sensory experience. The same should apply to the social experience with the host to set adequate expectations with regards to this important aspect of CC customer experience in hospitality.

Limitations and further research avenues

One limitation of this study is its young sample. It is, however, representative of the typical consumers of CC hospitality accommodations. An additional limitation stems from the fact that the same sample was used for both exploratory and confirmatory analyses. Moreover, the analysis has shown a potential lack of discriminant validity between "Social experience with the host" — a subdimension of the CC hospitality service experience — and "Quality of interaction with the host" — a subdimension of the CC hospitality service quality. Future research would gain by investigating the potential benefit of merging both constructs to

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develop a specific measure for an overall CC social experience that would shed more light on the key role of the host in a CC context.

Moreover, given its importance in the P-to-P hospitality sector, Airbnb has been used as a context to provide to participants so they can all refer to the same provider when responding to the questionnaire. Further research may include other service providers in the hospitality sector in order to validate the consistency of the structure of our scale in a CC context. Besides, our scale has been specifically developed for the P-to-P hospitality context. Other CC platform contexts, such as transportation (e.g., Uber, Lyft), for instance, have specific issues affecting customer experience, such as the scepticism about customers' safety that has been raised in recent years, thus undermining the brand's effort to offer a better customer experience than its conventional competitors (e.g., taxis).

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Does Humour Enhance Facebook Users' Responses?

Study of the Impact of Humour on Customers' Engagement

Fatma Smaoui
University of Tunis, ISG Tunis, LARIME Lab.

Fatma Choura
University of Tunis El Manar, ISI Tunis, LIGUE Lab.

Mohamed Wassim Abassi
Digital advertising agency

Hela Zouaoui
University of Tunis, ISG Tunis, LARIME Lab.

Abstract: In a context of overabundance of information on social media, the challenge for an organization is to stand out and to create a link with its target. A Facebook page is a means for a company to federate the users around communities and to drive their engagement. The objective of this research is to test the effect of the use of humour in Facebook posts on perception, attitude and intention of engagement of social media users. An experimental study was conducted on a sample of fans of a Facebook page where we manipulated absence/presence of humour, and humour types. Results show a positive effect of perceived humour on attitude toward the publication, which influences the Facebook user's intention to engage. Need for humour does not moderate the effect of humour on the attitude and the results do not reveal any difference between the types of humour tested.

Keywords: Humour, Engagement, Need for humour, Facebook, Tunisian context

Introduction

Today, communicating on the Internet and on social networks has become essential for any business, given the impact of technological growth on the media scene and consumer dynamics (Dahlen & Rosengren, 2016). Recent statistics demonstrate that the Internet is projected to represent the most favoured advertising medium, accounting for more than 65 percent of global ad expenditures in 2024 (Statista, 2022a). Online advertising is rapidly growing, mainly supported by ads on social networks.

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Today, Facebook (FB) offers a company a powerful virtual communication space, due to the importance of its audience and the possibilities of interaction it offers. With roughly 2.89 billion active users monthly in 2021, Facebook is the biggest social network worldwide (Statista 2022b) and counts for one quarter of total digital advertising spending in the US (E-marketer, 2021). It represents the benchmark platform for Business-to-Business and Business-to-Consumer companies that would offer the best Return on Investment. Through their Facebook page, companies seek to develop virtual communities and interact with their target audience.

Increasing the engagement of users towards social media becomes, thus, one of the major goals of a digital communication strategy (Gummerus *et al.*, 2012; Pezzuti, Leonhardt & Warren, 2021) as it is considered to be the best way to increase the reach of a business. Accordingly, humour can be one of the ways to improve this engagement and generate Internet users' interest, especially since these latter are present in an overwhelming environment characterized by information and advertising overload (Ge & Gretzel, 2018; Dolan *et al.*, 2019).

The literature on humour in a digital context remains to be developed compared to the abundant research on humour in advertising in general (Shifman & Blondheim, 2010; Taecharungroj & Nueangjamnong, 2015; Weinberger & Gulas, 2019). Used in communication messages, humour can help attract consumers' attention, improve their understanding of the related message, and induce a positive attitude towards it, as well as towards the brand (Madden & Weinberger, 1982; Zhang, 1996; Eisend, 2011). Thanks to its ability to generate positive emotions and initiate social interactions, humour can be a powerful means of communication in a digital context (McGraw, Warren & Kan, 2015; Ge & Gretzel, 2018; Pezzuti, Leonhardt & Warren, 2021). This effect is reinforced by great possibilities of interaction between consumers, rendered possible thanks to the Web 2.0, as well as the diversity of expressions of humour allowed by digital technology (Shifman, 2007; Ge & Gretzel, 2018). Therefore, many of the effects of humour examined in traditional advertising settings may not be extendable to social media engagement behaviours (Barry & Graça, 2018). Indeed, social media is mainly characterized by interactivity and virality (Yeo *et al.*, 2020). Some authors evoke a paradigm shift, evolving from a one-way communication in advertising to conversational communication where consumers are active contributors (Ge & Gretzel, 2018). Thus, Internet users' engagement, such as commenting or sharing messages, becomes a central marketing effectiveness measuring tool of marketing effort on social media. Despite this, little is known today about the impact of humour messages in a digital context and particularly on customers' engagement (Yeo *et al.*, 2020; Barry & Graça, 2018).

The effect of humour on consumer reactions remains dependent to a number of individual factors, such as personal traits. In particular, individuals may react differently to humorous messages depending on their need of humour (NFH), i.e., their tendency to generate humour

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or to seek for it (Cline, Altsech & Kellaris, 2003). Humour effectiveness depends also on message characteristics like humour types (i.e., joke, pun, comedy, satire) (Weinberger & Gulas, 1992; Crawford & Gregory, 2015; Oikarinen & Söderlund, 2016). Managers and content creators may wonder which type of humour, as an executional message dimension, is the most effective. So far, little is known about the effectiveness of message humour types. Gulas & Weinberger (2006) underline the lack of interest of advertising research on this topic, in addition to the fact that research findings are globally non-conclusive and divergent (Taecharungroj & Nueangjamnong, 2015). Finally, the impact of humour on consumer reactions depends as well on cultural context. Empirical evidence indicates that people of different cultural backgrounds respond to humour differently (Weinberger & Gulas, 1992; Kuiper *et al.*, 2010). For instance, humour seems to be an important element in the daily life of certain Arab countries, especially since the Arab Spring revolutions of 2011 (Moalla, 2015; Alharthi, 2014). Nevertheless, only little marketing research has been conducted in non-Western settings (Ge & Gretzel, 2018; Yeo *et al.*, 2020).

In a context where studies on humour in a digital environment are relatively limited, especially in the Middle East and North Africa region and Tunisian context, this research aims to investigate the effect of humour used in Facebook posts on humour perception, attitude about the post and intention to engage with that post. Specifically, we will test the effect of presence versus absence of humour, along with the effect of humour types, on Internet users' reactions. The moderating role of the need for humour is considered.

This paper is structured in four parts. First, a literature review on the use of humour in advertising and digital communication, and on its impact on perceptions, attitudes and engagement is presented. This theoretical background allows the development of research hypotheses. Then, the methodological approach is detailed, including a preliminary qualitative study and an experimental design. The results are presented in a section that follows. Finally, we conclude with discussion of results, contributions, limitations and future research paths.

Theoretical Background and Hypotheses

Humour in advertising communication

Defining the concept of humour is a complex task because of its multiple facets and meanings (e.g., psychological, sociological or philosophical). Humour can be interpreted as a psychological state (seen as amusement, fun), as well as a behavioural tendency to laugh at the stimuli that elicit it (Gulas & Weinberger 2006; Warren, Barsky & McGraw, 2018). Meyer (2000) views humour as a means of providing fun and pleasure, initiating social interactions and generating emotional responses from an audience. Humour is not expressed in a unique

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way; several typologies have been proposed (Goldstein & McGhee, 1972; Kelly & Solomon, 1975; Catanescu & Tom, 2001). The most common is that of Speck (1991), which proposes a taxonomy of five types of humour classified according to the induced psychological mechanisms: Comic wit, sentimental humour, satire, sentimental comedy, and full comedy (Appendix Table A1). This humour taxonomy is based on three basic humour processes: arousal-safety, incongruity-resolution, and humorous disparagement. Catanescu & Tom (2001) identified seven types of humour in the context of broadcast and print media (comparison, personification, exaggeration, pun, sarcasm, silliness, and surprise). Besides, humour perception and interpretation are individually and culturally laden. Humorous messages can be perceived as (not) funny according to personal sensitivity and cultural settings (Alden, Hoyer & Lee, 1993; Ruch & Hehl, 1993).

Humour in digital communication strategies

Literature established that social media messages influence significantly consumers' attitudes and behaviours, thanks to their interactive character that facilitates their dissemination and sharing (Brown, Bhadury & Pope, 2010; Botha & Reyneke, 2013). Indeed, humour and social media are intrinsically associated with sharing (Ge & Gretzel, 2018). Advertising content's ability to generate emotions increases the probability of their diffusion on the Internet, particularly when they are funny and entertaining (Dobele *et al.*, 2007). Accordingly, ads that contain humour are among the most shared ones on social media networks (Berger & Milkman, 2012; Schifman, 2012). Interactivity allowed by Web 2.0 and digital technologies have created new humour techniques, such as PowerPoint files and interactive humour, which contribute to the spreading of humorous messages on Internet sites and their effectiveness (Shifman 2007; Ge, 2019). Shifman (2007) identifies six new formats of humorous messages specific to the Internet: Interactive humour, where the Internet user is invited to add humorous elements; the "Funny photo" (photo accompanied by a funny text) broadly known in the contemporary digital world as memes; the Maniphoto (photo manipulated digitally); Phanimation (static photo subject to animation); Celebrity soundboard (collection of sound clips from celebrities from films, radio or TV); and humorous PowerPoints.

Ge & Gretzel (2018) pointed out the emergence of new digital linguistic expressions in social media (e.g., hashtag, animated GIF, smiley, like, share) stimulated by the development of digital technology and the creative and participatory culture on the Internet. These new digital expressions offer consumers a wide variety of responses to humorous messages taking place behind a screen through various forms expressing different degrees of users' engagement. Beyond the "like", for example, humorous messages provide the ability to initiate various types of sharing, including sharing as dissemination (viral message), sharing as participation

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(generating cooperative actions by the audience), and sharing as communication (where humour is used as a language of communication) (Shifman, 2012). On contemporary social networks, consumers express the need to share their daily lives and experiences; which contribute to shaping their digital identities. All social networks respond to this need for sharing and brands find it an interesting and timely field to generate the engagement of Internet users and thus increase their visibility among them.

Impact of humour on the social media user's perception and attitude

The perception of the humorousness of a message depends on consumers' individual characteristics as well as content elements (Madden, Allen & Twible, 1988; Flaherty, Weinberger & Gulas, 2004). Speck (1987) tested the effect of different types of humour on consumer responses (i.e., attention, liking, Attitude towards the Advertisement (Aad), message comprehension). Results suggested that full comedy has the strongest general effect on some consumer reactions, while sentimental humour was found to outperform other humour treatments on message comprehension. Further research produced divergent and non-conclusive results. Hatzithomas, Zotos & Boutsouki (2011), for example, found comic wit to be the most popular type of humour, while Barry & Garça (2018) suggest that there are no significant differences in the performance of the Speck (1991) taxonomy humour types tested. Likewise, Taecharungroj & Nueangjamnong (2015) found that the two most frequent types of humour used in social media memes are sarcasm and silliness, but they report no obvious differences observed in the effects of seven types of humour tested on virality of memes on Facebook posts.

Therefore, it seems that it is more the presence of the humorous content that influences perceptions rather than the categories of humour used in the message. Respondents in the humour condition, compared to those in the no-humour one, will experience greater responses, which we propose to test in the hypothesis H1.

H1: A Facebook post with a humorous element generates a higher perception of humour among Internet users than a non-humorous post.

Several studies have shown that the advertising content perceived as humorous has a positive impact on consumers' perceptions of products and improves attitude towards the advertisement and the brand (Chung & Zhao, 2003; Lee, Hosanagar & Nair, 2018; Eisend, 2009; Barry & Garcia, 2018). Indeed, research on advertising attributes to ad perceptions a decisive role in shaping attitude towards the advertisement (Aad) (Mackenzie & Lutz, 1989), which is also confirmed in the context of Internet advertising (Burns & Lutz, 2006; Tafesse, 2015; Ge & Gretzel, 2018). Thus, positive perceptions towards an advertisement would favour the creation of a favourable attitude, in particular when this perception is linked to the

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entertaining nature of the advertisement. Consequently, the perception of a humorous advertisement as non-humorous could have negative effects on the attitude towards it. The perceived humour degree of an advertising message is therefore a significant antecedent of the attitude of the Internet user to this message (Flaherty, Weinberger & Gulas, 2004). Hence the statement of hypothesis H2:

H2: The more a FB message is perceived as humorous, the more the attitude towards it is positive (Aad).

The need for humour: a moderator of Internet user's response

The response to humorous content may differ from one person to another. Accordingly, the studies by Cline, Altsech & Kellaris (2003) and Cline, Kellaris & Machleit (2011) emphasized that individuals present humour needs to different degrees, which can significantly influence their responses to humorous stimuli. "Need for humour" (NFH) is a construct derived from individuals' need for levity. It can be defined as a personality trait that reflects a person's tendency to generate humour (interior NFH) or to seek it (exterior NFH) (Cline, Altsech & Kellaris, 2003). Scholars found NFH to play a moderating role in humour studies: for people who have high levels of NFH, the response to a humorous stimulus will be greater (Cline, Altsech & Kellaris, 2003; Crawford & Gregory, 2015; Yeo *et al.*, 2020). Hence, we expect individual NFH to moderate the relationship between perceived humour and attitude toward the advertisement. We propose the following hypothesis:

H3: The need for humour moderates the relationship between the Facebook message perceived humour and the attitude towards the message (Aad).

The Internet users' engagement

In digital marketing, users' engagement is a central measure of the effectiveness of communication on social media (De Oliveira Santini *et al.*, 2020). This indicator reflects an individual's motivation to interact with content on social networks and Facebook pages in particular (Baldus, Voorhees & Calantone, 2015; Dessart, Veloutsou & Morgan-Thomas, 2015). Engagement is generally measured by the number of likes, comments and shares of a post on the Internet (Smith, Fischer & Yongjian, 2012; Pezzuti, Leonhardt & Warren, 2021). Previous literature established that a positive attitude towards the ad influences positively the purchase intention (Edell & Burke, 1987; Lord, Lee & Sauer, 1995). This significant relationship between Aad and intention to behave in a certain way may allow us to suggest that a positive attitude towards a post on an FB page can give rise to an intention to react to this stimulus in the form of an intention to like, comment or share; hence the hypothesis H4.

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H4: A positive attitude towards a Facebook message increases the user's intention to engage in terms of: intention to like (H4.1); intention to comment (H4.2); and intention to share (H4.3).

Methodology and Empirical Approach

To test our hypotheses, experimentation was conducted among Facebook users to test their reactions to different humour conditions relating to humorous Facebook posts (non-humour vs humour types). We conducted an exploratory qualitative study with digital communication experts in Tunisia as a preliminary step to the experimentation, in order to better understand the uses of humour in digital communication in Tunisia.

Preliminary qualitative study

Six semi-structured in-depth interviews were conducted with digital communication professionals in Tunisia in order to better understand the characteristics and practices of humour in communication within the specific cultural context of this study and to identify the forms of humour most used on social networks in it (Appendix Table A2). The interviews lasted between 30 and 60 minutes and were audio-recorded and transcribed. A thematic content analysis was performed on this qualitative material (Miles & Huberman, 1994).

Humour and advertising in the Tunisian context

The results show that humour is an integral part of the daily life of the Tunisian individual and her/his culture: *"... Especially in Tunisia, humour is a major distraction, acquired since childhood; it is part of the Tunisian culture and it presents specificities compared to other types of humour, such as Anglo-Saxon humour. The latter is a very fine humour; we are more on the side of the joke and the irony"* (Haythem, CEO). As for social networks, respondents say that humour is a very good stimulus for sharing publications; Tunisian Internet users often react to humorous content and posts. Our study also found that Tunisian individuals do not accept all forms of humour; they would be more attracted by the humour lived in everyday life translated into scenes of dramatization of reality, a common humour in which they recognize themselves.

In practice, the experts underlined the efficiency of the digital tool compared to television in terms of the effectiveness of humour, due to the significant capacities of creativity; as opposed to TV ads, considered as more formal. Regarding the performance of the types of humour, the experts interviewed agreed that the interaction of the Tunisian consumer with the humorous content of a communication depends more on the subject tackled and on the coherence of the message than on the type of humour deployed. They also specify that, in the same message,

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several types of humour can be found. Humour cannot thus tackle all subjects; there would be limits to be respected, in particular when it deals with taboo subjects like religion.

Types of humour most frequently used in the Tunisian context

The perception of the humorous nature of a message depends on the cultural context (Weller, Amitsour & Pazzi, 1974; Kuiper *et al.*, 2010; Crawford & Gregory, 2015). For the purposes of the experimental study, rather than reproducing a typology proposed by the literature and developed in the Western contexts, we preferred to identify the types of humour most frequently used in the Tunisian context. Therefore, we presented to our respondents a list of the three main taxonomies of humour proposed in the literature (Speck, 1991; Goldstein & McGhee, 1972; Kelly & Solomon, 1975) (Appendix Table A1). We then asked them to classify these types according to the frequency of their use in marketing communication in Tunisia. We identified the following three types as being the most recurrent: full comedy (ridiculous situation that makes people laugh with its unusual, different or surprising aspect); aggressive humour (aims to mock and ridicule); and pun word games (using a word or phrase that suggests two or more interpretations). This classification allowed us to better specify our explanatory variables and to design our experimental stimuli.

In the light of theoretical developments and the results of the qualitative study, a research model is presented in Figure 1, expressing the different variables' relationships and the relating hypotheses.

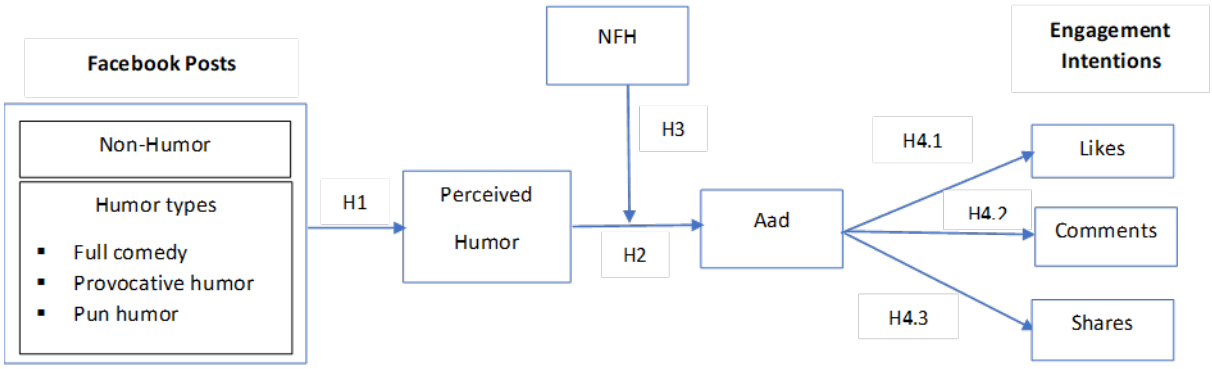

Figure 1. Research model

Experimentation

General design

We used a one-factor between-subject experimental design to test the hypotheses. Four different versions of Facebook posts were developed to serve as stimuli; three of them contained humour, while the fourth version did not contain humour. After being randomly

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exposed to one of these messages, participants were asked to complete a questionnaire to measure their reactions to stimuli. Participants were members of a Facebook page that we created for the purpose of this experiment.

Choice of the Facebook page

A Facebook page has been created and animated for the purpose of this study. The goal was to build a community of fan members, who will form our target population for the empirical survey. The choice of the theme of the page was guided by two considerations: (1) a "neutral" theme not related to a brand, nor to a commercial product, to avoid causing controversy; and (2) a "popular" theme that could interest the social media users and provoke their fast adhesion to the page. Through our qualitative survey, we identified the following themes: music, cinema, animals (dogs). After a pilot online survey among 37 Internet users, the preferred theme identified was "animals — dogs" (44.5%) that was considered for the final experiment. It is interesting to note that "animals" has been considered as a global-oriented humour topic by researchers (Shifman, 2007; Laineste & Voolaid, 2016). The purpose of the Facebook page is the "exchange of all types of information on dogs". To choose the name of the page, we used brainstorming with 6 Facebook users. Three names were proposed: "The dogs"; "A dog's life"; and "Our friends the dogs". An online survey with 40 other Internet users allowed us to choose the name "Our friends the dogs" (55% prefer this name). We then launched the page, which was animated by content in various formats (e.g., text, image, video) on the chosen theme, for a period of 45 days.

Stimulus development

Four Facebook posts were developed: three with humour (full comedy, pun and aggressive humour) and one control version without humour. The sensitivity and appreciation of humour depend on the individual characteristics of the consumers (Ruch & Hehl, 1993; Cline, Altsech & Kellaris, 2003). Varying the types of humour allows us to broaden the scope of proposed humour and target Facebook users of various sensitivities.

We have chosen the format "Funny photos" (Shifman, 2007), known today as memes (an image with a short text). Shifman describes this format as the most used in digital publications because of its simplicity and ease of production. Several studies have emphasized the efficiency of the visual elements of an Internet publication over textual or videographic elements (Sabate *et al.*, 2014; Hoeffler & Schwartz, 2011). This was confirmed by the interviewed experts as well, who argued that images generated more interaction than text or video in Tunisia.

We carried out a Google image search on the Internet, which allowed us to select 4 images representing dogs relating to the 4 experimental treatments. With the help of a computer graphics expert, we manipulated these images and added text. It should be noted that these

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experimental stimuli were dominated by image, as the reduced textual content did not raise difficulties of understanding, nor of interpretation. In order to validate our choice of images, we asked a group of 35 Internet users to assign each of these images to one of the 4 types of treatment considered (non-humorous, Pun, aggressive humour, and full comedy humour). The classification confirmed the choice of images (significant X^2 test conducted on this classification, $X^2 = 359.827$; sig = 0.000). Subsequently, we integrated these images into the questionnaires.

Questionnaire, data collection and participants

Once the FB page was launched, a community of nearly 1000 fans was formed throughout a period of 45 days of work to animate the content of the page. At the end of this period, we carried out the experimental study using a questionnaire administered to members of the community.

Four versions of the same questionnaire were developed. The only difference between them was the stimulus, which is the image contained in the questionnaire (funny photo). The instruction given to the respondents was that this photo is proposed to be posted on the Facebook page, "Our friends the dogs". So, respondents were asked to respond to the different questions. The questionnaire was administered online to the 1003 members of the page randomly assigned to four equal groups. Finally, we obtained 172 valid responses (45% men, 55% women), an average of 43 responses for each treatment.

Measures

Intention to engage was measured through three variables (intention to like/comment/share). These dependent variables were carried out in the questionnaire immediately after exposure to the image of the Facebook post (Wetzel, 1977 ; Yeo *et al.*, 2020). All variables were scored on a 5-point Likert scale (strongly disagree to strongly agree). Scale items for assessing key constructs were adapted from prior studies' validated measures: perceived humour (Zhang 1996); Aad (Cline, Altsech & Kellaris, 2003); intention to engage (Oikarinen & Söderlund, 2016); and NFH (two dimensions, interior NFH and exterior NFH; Cline, Altsech & Kellaris, 2003). The details of measurement scales are presented in Appendix Table A3.

Results

Data analysis methods

We use a one-way Analysis of Variance (ANOVA) to assess the experimental manipulation and to test the effect of the four humour conditions (without humour; 3 types of humour) on the perceived humour of the Facebook posts. We applied Partial Least Squares (PLS) path modelling, a variance based, structural equation modelling (SEM) technique, to estimate and

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analyze causal relationships between latent variables. PLS is suitable for structural measurement models and for testing and validating models. It is a more appropriate technique for small to medium sample sized, complex models, and is capable of modelling latent constructs under non-Normal conditions (Chin & Newsted, 1999; Hair, Howard & Nitzl, 2020; Hair *et al.*, 2014). More recently, several researchers have recognized the value of PLS as an SEM technique (Petter, 2018). The minimum sample size requirements are met in the present study: as the maximum number of arrows pointing at a latent variable is six, we would need 60 observations, according to the 10-times rule (Hair *et al.*, 2014, p. 18).

As for analyzing the data, this research uses SmartPLS 3.0 software (Ringle, Wende & Becker, 2015). A two-step analytical approach is followed: first the outer measurement model is tested; then the inner structural model is estimated (Hair *et al.*, 2014). Consequently, we will present, in the following sections, the measurement model validation, followed by the experimentation results and the tests of the hypotheses.

Measurement model assessment

To establish the measurement scale's reliability and validity for each of the reflective measurement constructs, we ran the PLS algorithm followed by the standard bootstrap procedure with 500 bootstrap samples to establish statistical significance. Examining the results, we removed items that have low loadings (less than 0.708) (Hair *et al.*, 2014, p. 103) to meet the criteria of individual item reliability. In all, we deleted an item from each of the three customer engagement measure scales, and three items from each of the two NFH constructs. Table 1 summarizes the item loadings of the different measurement scales, as well as the reliability and validity coefficients of these scales. Results show an adequate internal consistency for the constructs, as Cronbach's alpha and composite reliability (CR) coefficients are above the threshold of 0.7 for each construct (Bagozzi & Yi, 1988; Hair, Howard & Nitzl, 2020). Convergent validity was assessed using the average variance extracted (AVE). An AVE of 0.50 or above confirms convergent validity (Hair, Howard & Nitzl, 2020). The AVE of all reflective constructs achieved values between 0.60 and 0.830, confirming that all measures demonstrated satisfactory convergent validity. Discriminant validity is demonstrated when the shared variance within a construct (AVE) exceeds the shared variance between the constructs (Fornell-Larcker, 1981). Table 2 shows that the square root of the AVEs of all constructs is greater than the highest correlation value for other constructs. Discriminant validity is confirmed. Appendix Table A4 shows the cross-loadings of items, where item loadings for their own constructs are higher than loadings for the other constructs, confirming the discriminant validity of the latent variables.

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Table 1. The measurement model: Item loadings and reliability of constructs

Construct	Item	Standardized Loading**	Cronbach's Alpha	Composite reliability (CR)	Average variance extracted (AVE)
Perceived humorousness	Hum1 Hum2 Hum3	0.862 0.845 0.895	0.836	0.901	0.753
Aad	Aad1 Aad2 Aad3	0.923 0.922 0.839	0.875	0.924	0.802
NFHI (Interior)	NFHI3 NFHI4 NFHI5	0.754 0.960 0.765	0.805	0.869	0.692
NFHE (Exterior)	NFHE2 NFHE3 NFHE6	0.814 0.878 0.743	0.749	0.854	0.660
Intention to like	Like1 Like2	0.936 0.892	0.807	0.911	0.836
Intention to comment	Comt1 Comt2	0.899 0.923	0.796	0.907	0.830
Intention to share	Share1 Share2	0.878 0.915	0.758	0.804	0.804

** all the loadings are significant at $p < 0.001$

Table 2. Discriminant validity of constructs

	Aad	Comment	Perceived humour	Like	NFHI	NFHE	Share
Aad	0.896						
Comment	0.436	0.911					
Perceived humour	0.688	0.509	0.868				
Like	0.600	0.489	0.535	0.914			
NFHI	0.067	0.187	0.137	0.176	0.832		
NFHE	0.025	0.038	-0.014	0.097	0.384	0.813	
Share	0.399	0.706	0.442	0.569	0.177	0.004	0.897

Hypotheses testing

To test our hypotheses, we performed first a one-way ANOVA to establish the effect of humour condition treatments on the perceived humour of FB posts. Then, the inner structural model was assessed and the different variables' relationships estimated.

Experiment manipulation check

To assess the experiment manipulation, we computed the mean score of the FB post perceived humour variable for the four groups (Table 3). A one-way ANOVA was conducted and showed that perceived humorousness was higher in the groups receiving the humorous versions of the message compared with the group who received the non-humorous version ($F = 6.67$, $p = 0.000$), thereby verifying the convergent validity of the manipulation (Perdue & Summers, 1988) (Table 4). A Scheffe Post Hoc test showed that each humorous funny image produced a significantly higher level of perceived humorousness than did the non-humorous image.

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However, the Post Hoc test shows no significant difference in perceived humorousness between the three humorous versions (Table 4): thus, hypothesis H1 is supported.

Table 3. Mean for the treatment groups (standard deviations in parentheses)

Condition treatment	Non-humour	Aggressive humour	Full comedy humour	Pun humour
Mean (SD)	2.90 (0.99)	3.48 (0.98)	3.80 (0.86)	3.59 (0.97)
N	43	42	44	43

Table 4. Facebook message perceived humour, mean scores(M) and Post Hoc test

Message content (I)	Message content (J)	Means' difference (I-J)	ErrorStd	Sig.
Non-humour	Aggressive humour	-0.5772	0.2115	0.06
	Full comedy humour	-0.8961	0.2090	0.001
	Pun humour	-0.6822	0.2102	0.017
Aggressive humour	Full comedy humour	-0.3189	0.2103	0.514
	Pun humour	-0.1050	0.21152	0.970

Structural model assessments

The first step is to examine the path coefficients of the developed relationships. Path coefficients indicate the strength of the relationships between the independent variables and dependent variable. Table 5 provides estimates of the structural model relationships along with the moderating variables and hypothesis testing. These latter are discussed in the following.

Table 5. Path coefficients and hypothesis testing

Hypothesis	Relationship	Beta	T value	P value	Results
H2	Perceived humour -->Aad	0.688	15.557	0.000	Supported
H4.1	Aad --> Like	0.600	8.810	0.000	Supported
H4.2	Aad --> Comment	0.436	6.447	0.000	Supported
H4.3	Aad --> Share	0.399	5.637	0.000	Supported
H3	NFHI*perceived humour -->Aad	0.009	0.829	0.408	Not supported
	NFHE*perceived humour -->Aad	0.052	0.722	0.471	Not supported

Main effects: Initially, Hypothesis 2 proposes that perceived humour impacts positively on Attitude towards the FB post (Aad). The results presented in Table 5 have revealed a significant positive relationship between perceived humour and Aad: the higher the perceived level of humour, the better the attitude towards FB posting. Hypothesis H2 is supported. The results also report a positive relationship between Aad and each of the three measures of engagement intentions. The three path coefficients are positive and significant, indicating that the more the attitude towards the post is favourable, the more the Facebook user will tend to like, comment and/or share. Table 5 also shows that the highest path coefficient is associated with the variable "intention to like the post" (beta = 0.600, p= 0.000). Hypotheses H4.1, H4.2 and H4.3 are supported.

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Moderation effect: H3 proposes that NFH moderates the relationship between perceived humorousness and Aad. NFH is a continuous variable; consequently, we adopted the product indicator approach in PLS-SEM to detect and estimate the strength of the NFH moderating effect on the Attitude towards the FB post (Kenny & Judd, 1984; Henseler & Chin, 2010; Hair *et al.*, 2014). The moderation test reported in Table 5 shows non-significant results. Path coefficients of the interaction terms relating to Internal NFHI (beta = 0.009; p = 0.408) and external NFHE (beta = 0.052; p = 0.471) are very low and non-significant. Hence, H3 is not supported for both dimensions of NFH. It should be noted that the average mean score for each of the two NFH dimensions is relatively high, indicating a high level of the Need for Humour among the Tunisian sample interviewed (Internal NFHI Mean = 3.79, SD = 0.769; External NFHE Mean = 4.239, SD = 0.534).

Model validity: Table 6 reports the inner model validity criteria. The most commonly used measure to evaluate the structural model is the coefficient of determination, R^2, which is a measure of the model's predictive accuracy and exploratory power (Hair *et al.*, 2014). This coefficient represents the exogenous latent variables' combined effects on the endogenous latent variable. Results suggest that 47% of the variation in Aad could be explained by the perceived humour of the FB post. On the other side, Aad helps to explain 36% of the variance of the intention to like the post, 19% of the intention to comment and 15.9% of the intention to share. Whereas it is difficult to provide rules of thumb for acceptable R^2 values, as they depend on the research discipline and the model complexity (Hair *et al.*, 2014), values over 0.2 can be considered as having an acceptable predictive power in social sciences, since the lowest recommended level is 0.1 according to Falk & Miller (1992).

Table 6. PLS inner model validity: R squared and cross redundancy (Q^2)

Dependent construct	R squared (R^2)	Q^2 (cross redundancy)
Aad	0.473	0.373
Intention to like	0.360	0.121
Intention to comment	0.190	0.147
Intention to share	0.159	0.121

The Stone-Geisser Q^2 (cross validated redundancy test) is used to evaluate the model predictive relevance (Geisser, 1974; Stone, 1974). The Q^2 values reported in Table 6 are above zero for all the dependent variables. This indicates that the endogenous constructs involved in this model have a strong predictive relevance. Moreover, Q2 values above 0.35 indicate substantial predictive relevance for explaining the variable studied (Henseler, Ringle & Sinkovics, 2009).

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Discussion and Conclusion

Marketing on social media is different from traditional marketing and requires a rethinking of approaches and of the overall marketing mindset, shifting from an advertising to a conversational paradigm (Ge & Gretzel, 2018). In fact, the main characteristic of the Internet and social media is the interactivity allowed between companies and consumers and between users. Interactivity leads to a transition from a one-way communication in traditional advertising to an interactive communication, where consumers are active contributors to the effectiveness of marketing efforts.

Indeed, on social media platforms, one of the main criteria for measuring the effectiveness of the marketing effort is the user's engagement with posts and communications. Humour offers a way for a company to differentiate itself and to raise the interest of the social media user. While the effectiveness of humour in traditional media and in advertising has been relatively well studied, research on the use of humour in digital media is still limited. Recent studies on this subject have focused on the use of humour during the COVID-19 crisis (Hussein & Aljamili, 2020).

The purpose of this research is to study the effect of humorous content in Facebook posts on intention of users to engage with messages conveyed on social media. A qualitative study was carried out with digital communication professionals in Tunisia, followed by an experiment with fans of a Facebook page. The main results showed that:

- In the Tunisian context, humour is deeply rooted in the daily life of individuals and in their culture. The consumer would be particularly sensitive to humour and would use it for distraction, but also to escape from a monotonous and difficult everyday life. These results join those of Alharthi (2014), who describes humour as an essential element of the daily life of individuals in Arab countries, and those of Moalla (2015), who found that humour in Tunisia has been developed a lot, in particular on social networks, and since the 2011 revolution. She explains this development by the freedom of expression regained after the 2011 revolution, along with the role that humour plays in compensating for a feeling of uncertainty, confusion and lack of security. Other studies show that, when faced with psychological distress, the individual can use humour to compensate for stress (Blank, 2013). This stress can be generated in part by the ultra-information universe in which the individual now lives and where entertainment has become a real need. The search for fun and entertaining content by the Tunisian consumer, in particular with regard to the results of this qualitative and quantitative study, should be considered as an opportunity for brands to integrate the humorous dimension into their content and communicated messages in order to generate more reactions and therefore a better engagement rate.

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- Regarding themes and types of humour, the qualitative study revealed that humour in marketing communication cannot tackle all themes, and that certain subjects remain taboo, such as religion. Certain types of humour are not appreciated by the Tunisian consumer, such as dark humour. In Tunisia, individuals are more focused on simple, light humour, rooted in their daily lives. Accordingly, the types of humour most frequently used in marketing communication are, according to experts, the full comedy, aggressive humour, and Pun or word games. However, these professionals believe that the effectiveness of humour is more dependent on the humour theme addressed than on the type of humour.
- The results of the experiment show that the presence of a humorous content (vs absence) in a Facebook post induces higher users' intention of engagement. This positive effect is the result of a mental process of perception and attitude formation. The higher the perception of humour is, the better the attitude towards the message (Aad) will be. This attitude then positively influences the intention of engagement in terms of intention to like, comment and share the FB post. Our results join those of previous research establishing the positive impact of humour in advertising on the attitude towards the advertisement (Eisend, 2009; Chung & Zaho, 2003; Cline, Altsech & Kellaris, 2003; Barry & Garcia, 2018) and on the engagement of social media users (Tafesse, 2015; Ge & Gretzel, 2018; Lee, Hosanagar & Nair, 2018). By stimulating pleasure and inducing positive emotions, humour pushes the individual to interact, initiate social relationships and share their emotions and attitudes (Eisend, 2011; Berger & Milkman, 2012). Social media has created a new paradigm, that of sharing opinions, experiences and interactions in a virtual space. It is the ability of humour to initiate social relationships that can make it a powerful tool in the context of social networks. Humour has been revealed in the literature as an element favouring positive reactions (memorization, perception, implication), even when it is used in "negative" situations of discomfort, violence, dissatisfaction or complaint (Brown *et al.*, 2010; McGraw, Warren & Kan, 2015).

  The intention to like has been most impacted by humour. This is a rather expected result because of the simplicity of the mention "like" that makes it the most common interaction on Facebook and which corresponds to a capital attention and a sign of affinity (Cordina & Fayon, 2013).

- Our results do not allow us to establish the superiority of one type of humour over another in Tunisia. The level of humour perceived does not vary according to the type of humour but, rather, according to the absence or presence of humour. These results are in line with the findings of Barry & Garça (2018) that established that no significant differences were found in advertising attitude or generated comments of comic-wit humour when compared

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to all others of Speck's types of humour. In the Tunisian context, our results can be explained by the idea developed by the experts interviewed, according to whom the effectiveness of a humorous communication would depend more on the chosen theme and the coherence of the message than on the type of humour. For some of these professionals, the question of typology of humour is more a theoretical problem of categorization than a managerial one. They also point out that, in practice, a communication message (video example) can contain several types of humour.

- Finally, our results show that the need for humour (NFH) as an individual characteristic does not moderate the effect of humour on attitude towards digital messages, unlike previous research (Cline, Altsech & Kellaris, 2003; Cline, Kellaris & Machleit, 2011). This could be explained by the fairly high score of the NFH variable found in the sample of Tunisian Internet users, which could reduce the variance of this variable and therefore its effect. This explanation joins, on the one hand, the literature which establishes that humour, seen as a social phenomenon, is an integral part of the daily life of the individual in Arab countries and particularly in Tunisia (Moalla, 2015; Alharthi, 2014), and ,on the other, the comments of professionals who recognize an important place of humour in the Tunisian experience and culture.

On the managerial level, our research shows the importance of humour and the positive effect of its use in digital communications, which makes it a good lever of action available to professionals. Humour induces a positive attitude and promotes interaction and sharing. Communication companies can use humour to generate membership by Internet users and to help spread their communication among them. Companies can organize games, contests and calls for co-creation of content that revolves around humour, for example. Other research has found humour to be a hallmark of mimetic videos (videos imitating other videos) on YouTube (Shifman, 2012). In addition, the use of several message formats in digital spaces (e.g., image, video) and the ease of their technical manipulation will give Internet users the opportunity to be more creative and to share publications that they may have manipulated or diverted by giving them a humorous aspect. The recent success of the TikTok social media network is a good example of the success of humorous videos and messages.

This research may have certain limits that constitute openings towards future research avenues. We considered a simple model, with only one moderator variable, when, in reality, the effectiveness of humour depends on several other variables related to the content of the message, its format or even other cognitive, affective or socio-demographic characteristics of respondents. A more in-depth study would allow a better understanding of the relationship that consumers have with humour on the Internet and on social media networks in particular. Indeed, the pre-survey that we conducted allowed us to see that it is a fairly complex subject,

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and that certain cultural specificities are proved to be interesting to study. Considerations should be initiated to properly target and engage this hyper-connected Internet user everywhere and at any time. In addition, other formats for posting on Facebook can be tested in future research, including interactive formats that allow the user to create or co-create humorous situations. Indeed, the contemporary consumer is now endowed with significant power over networks and her/his involvement in the design of communication content represents a real opportunity for brands to build a close relationship with her/him and generate empathetic and more realistic messages.

In addition, the specificity of the digital context, marked by continuous and frequent technological innovations to which the user is now sensitive and receptive, requires that brands differentiate themselves by new communication formats that would better meet the ever-changing needs of the consumer (Dahlen & Rosengren, 2016). In this sense, tracking techniques and artificial intelligence could offer an interesting way to understand and anticipate consumers' responses and preferences for diverse humour message formats. Then, this study is mainly focused on reactions of Internet users to the different types of humour; it should also be interesting to extend these modalities and investigate the effectiveness of different levels of humour (low, medium, high).

This research also stopped at the study of the intentions of engagement of social media users in similar to but not real conditions of navigation. This limit may suggest continuing investigations to measure the real behaviour of Internet users exposed to humorous publications on Facebook, in terms of likes, with all the icons or smileys now offered by Facebook (laughter, sad, angry, etc.) to refine the expression of users' emotions, comments and sharing, recording the statistics on the page through an observational study. Beyond the statistics, a netnography of the comments would make it possible to analyze the reactions and behaviours of Internet users with humour, to better understand the tone of the exchanges as well as the motivations of Internet users' engagement.

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Appendix

Table A1. Humour taxonomies

Authors	**Speck (1991)**	**Goldstein & McGhee (1972)**	**Kelly & Solomon (1975)**
Humour typology	1- *Comic wit* (incongruity resolution, i.e., unexpected behaviour) 2- *Sentimental humour* (arousal-safety, i.e., taboos, childlike fantasies, naughtiness) 3- *Satire* (incongruity-resolution and disparagement) 4- *Sentimental comedy* (arousal-safety and incongruity-resolution) 5- *Full comedy (*rich form of humour, combination of satire and sentimental comedy)	1- *Aggressive humour* (provocative humour, to mock and ridicule) 2- *Sexual humour* 3- *Incongruous or nonsense humour*	1- *Pun* (Humorous use of words) 2- *Understatement* (representing something as less than is the case) 3- *Joke* (speaking or acting without seriousness) 4- *Ludicrous* (that which is laughable or ridiculous) 5- *Satire* (sarcasm used to expose vice or folly) 6- *Irony* (the use of words to express the opposite of what one really means; and what is most important) 7- *Intent* (perceived intent of advertiser to be humorous)

Table **A2. Professional interviewees' profiles**

Name	Gender	Age	Company and position	Years of experience in advertising
Haythem	Male	31	CEO of a Content creation agency	8 years
Rym	Female	39	Freelance Marketing communication consultant	12 years
Sarra	Female	26	Community manager at a digital marketing communication agency	4 years
Selim	Male	25	Media planner in a Tunisian office of a multinational communication marketing agency	3 years
Walid	Male	28	Digital manager in a Tunisian food company	4 years
Najla	Female	46	Head of an advertising consulting agency	15 years

Table A3. Variable measurement scales

Construct (source)	Indicators/Dimensions
Perceived humour (Zhang, 1996)	Hum1: Humorous Hum2: Funny Hum3: Amusing
Attitude toward Facebook post (Aad) (Cline, Altsech & Kellaris, 2003)	Aad1: Pleasant Aad2: Good Aad3: Favourable
Need for humour (NFH) (Cline, Altsech & Kellaris, 2003)	*Dimension 1: Internal NFHI* NFHI1: People expect me to say amusing things. NFHI2: I can crack people up with the things I say. NFHI3: I often come up with witty comments. NFHI4: I am good at thinking up jokes or funny stories. NFHI5: People tell me that I am quick-witted. NFHI6: I often feel the need to make other people laugh. *Dimension 2: External NFHE* NFHE1: I am a connoisseur of humour. NFHE2: I prefer situations where people are free to express their senses of humour. NFHE3: I enjoy being with people who tell jokes or funny stories. NFHE4: I often read jokes and funny stories. NFHE5: I enjoy being around quick-witted people. NFHE6: I need to be with people who have a sense of humour.
Intention to like Intention to comment Intention to share (Oikarinen&Söderlund, 2016)	Like1: It is probable that I like the FB post. Like2: It is possible that I like the FB post. Like3: It is most likely that I like the FB post. Comt1: It is probable that I comment on the FB post. Comt2: It is possible that I comment on the FB post. Comt3: It is most likely that I comment on the FB post. Share1: It is probable that I share the FB post. Share2: It is possible that I share the FB post. Share3: It is most likely that I share the FB post.

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Table A4. Cross-loadings of the outer variable model

	Aad	Comment	Perceived humour	Like	NFHI	NFHE	Share
Comt1	0.371	0.899	0.439	0.393	0.189	0.040	0.642
Comt2	0.422	0.923	0.487	0.492	0.155	0.030	0.644
Hum1	0.584	0.398	0.862	0.406	0.182	-0.034	0.351
Hum2	0.533	0.450	0.845	0.491	0.016	-0.024	0.387
Hum3	0.662	0.476	0.895	0.496	0.147	0.015	0.411
Like1	0.610	0.450	0.530	0.936	0.214	0.066	0.549
Like2	0.473	0.445	0.439	0.892	0.093	0.119	0.487
NFHE2	0.019	0.058	0.025	0.118	0.275	0.814	-0.036
NFHE3	0.025	0.090	-0.028	0.087	0.358	0.878	0.052
NFHE6	0.015	-0.100	-0.033	0.019	0.300	0.743	-0.028
NFHI3	0.024	0.155	0.083	0.149	0.754	0.492	0.119
NFHI4_	0.080	0.169	0.137	0.177	0.960	0.287	0.163
NFHI5	0.029	0.161	0.108	0.097	0.765	0.351	0.167
Share1	0.326	0.613	0.397	0.445	0.156	-0.026	0.878
Share2	0.387	0.651	0.397	0.567	0.162	0.029	0.915
Aad1	0.923	0.397	0.608	0.555	0.145	0.007	0.364
Aad2	0.922	0.428	0.580	0.577	0.133	0.058	0.385
Aad3	0.839	0.345	0.663	0.476	-0.106	0.001	0.322

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Technology-enabled Personalization for Mobile Banking Services

Literature Review and Theoretical Framework

Moetez Khemiri
University of Jendouba, Tunisia
University of Manouba, LIGUE, Tunisia

Rim Jallouli
University of Manouba, ESEN, LIGUE, Tunisia

Abstract: New technologies are giving very interesting potential to the personalization of products and services, in particular of mobile services. The study of the literature shows that technology-based personalization is an important factor in the adoption of mobile services. However, previous researchers are not unanimous as to the nature of this role: some studies confirm the moderating or mediating effect of personalization on the relationship between the adoption factors stated in the Unified Technology Acceptance and Utilization Theory (UTAUT) and the intention to adopt technology-based services. Other researchers consider that personalization rather exerts a causal relationship on the adoption of technology-based services. This paper undertakes a literature review with the aim of clarifying the impact of new technologies, such as artificial intelligence, Big Data, Internet of Things and Block Chain, on the personalization of mobile banking services. Moreover, this study presents a synthesis of previous research examining the role of personalization in relation to the factors affecting adoption and the intention to adopt mobile banking. Finally, this research proposes a conceptual model that can serve as a basis for future empirical research in the context of mobile services. Results and discussion could guide future empirical research in this area.

Keywords: M-Banking, UTAUT, Technology-enabled Personalization, Mobile services, Literature Review

Introduction

Marketing practice, marketing education, and academic marketing research will all be evolved to an unprecedented level thanks to advances such as artificial intelligence, the Internet of Things and huge advances in computing and data analysis (Rust, 2020). One of the areas of

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marketing transformation is the personalization strategy. Personalization is defined as "a process that modifies the functionality, interface, information content or distinctiveness of a system to increase its personal relevance to an individual" (Blom, 2000). Advancements in technology have enabled companies to provide products and services increasingly individualized and responding to customer needs and preferences.

Three different forms of personalization are then identified according to the scope and the nature of used technologies: Traditional personalization covers the services provided by employees in face-to-face mode; online personalization, assisted by technologies that rely on databases describing the past customer behaviours; and the most recent form, technology-enabled personalization (TEP), which involves Artificial Intelligence, Internet of Things, Blockchain technology and cognitive technologies, to enrich client interactions and relationships (Riegger *et al.*, 2021).

In the banking sector for instance, personalized application solutions have considerably increased the capacity and efficiency of mobile banking services (Zalloum, Alghadeer & Nusairat, 2019). Personalization implies adapting the user interface and graphics based on the client needs. Then, personalized mobile banking applications require the use of customer profiles, customer preferences, contextualized prior usage data of the mobile banking service, and social media data (Albashrawi & Motiwalla, 2015).

The personalization of mobile applications is an emerging phenomenon that deserves the attention of researchers. In the literature studying applications, little attention has been paid to the role of personalization in the technology acceptance model (Cheng *et al.*, 2020). In this context, this study proposes to make a synthesis of previous research, studying the impact of technology-enabled personalization (TEP) on the adoption factors and the adoption intention of mobile banking services.

Firstly, this research offers a literature review clarifying the impact of emerging technologies on the personalization of mobile banking services. Secondly, this article presents a synthesis of previous research works that study the role of personalization in relation to the adoption factors and the intention to adopt mobile banking services. Based on the literature review results, this study proposes a conceptual model that incorporates the argued hypotheses in the context of mobile banking services, and related to the impact of personalization on the use intention.

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Mobile Banking Services and New Possibilities for Personalization Based on Technologies

Mobile banking services are associated with a high degree of mobility, which allows customers to easily access banking services anytime and anywhere (Baabdullah *et al.*, 2019). Moreover, mobile banking refers to the arrangement and benefit of banking and financial services using mobile telecommunications devices (Nair & Fasal, 2017). While traditional banking services were limited to physical channels, such as bank branches and Automated Teller Machines (ATMs), M-Banking has removed the physical limitations of daily banking activities (Merhi, Hone & Tarhini, 2019). By using mobile devices like mobile phones, laptops and tablets, banks allow customers to access services that refer to financial activities, such as money transfers, payments, purchases, cheque book requests, transaction alerts and account balance verification (Goh, Suki & Fam, 2014). In addition, the use of new Quick Response Codes (QR Codes) or Near Field Communication technology (NFC) enables bank customers to access a full range of ATM services, including cash withdrawal, money transfers, debt and bill payments (Dauda & Lee, 2015).

The role of new-age technologies extends to data analysis and insight generation. Certainly, the use of the Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML) and Blockchain will have an impact on current business data management processes. These technologies allow a company to deliver the right content to the right customer at the right time (Kumar, Ramachandran & Kumar, 2020). In addition, data science techniques and data analysis capabilities have a huge role in guiding and implementing segmentation, targeting and positioning strategies (Merhi, Hone & Tarhini, 2019).

Huang and Rust (2021) developed a three-stage framework for strategic marketing planning, incorporating multiple artificial intelligence (AI) benefits: Mechanical AI for automating repetitive marketing functions and activities; thinking AI for processing data to arrive at decisions; and feeling AI for analysing interactions and human emotions. At the segmentation targeting and positioning (STP) marketing strategy stage, mechanical AI can be used for segmentation (segment recognition), thinking AI for targeting (segment recommendation), and feeling AI for positioning (segment resonance).

Technology-enabled personalization (TEP) is defined as the integration of physical and digital personalization dimensions at the point of sale to provide individual customers with relevant, context-specific information, according to historic and real-time data in combination (Riegger *et al.*, 2021). An adaptive customization system allows the product to adapt iteratively over time to the personalized needs and desires of the customer, and this solution exceeds the

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recommendation systems, in the sense that it literally changes the product over time, rather than providing similar recommendations to previous choices (Rust, 2020).

Table 1 presents the main results of the literature review on technology-based personalization in the banking field according to the involved technologies, the areas of personalization as well as the examples mentioned to illustrate the new opportunities in the context of mobile banking. The studied corpus consists of 14 scientific papers published between the period 2012 and 2021. The papers' selection method starts with a search on Google Scholar using combinations of the following keywords: Personalization, Technology, Mobile service, Mobile application, Mobile Banking, AI, ML, Recommender System, IoT, Blockchain and Big data. Then, an attentive reading of titles and abstracts of results was helpful to retain relevant papers in the studied field.

Table 1. Summary of Prior Work on Technology-enabled Personalization

Technology	Personalization	Example	Reference
Artificial Intelligence	- Obtain information from large volumes of customer and transaction data, involving not only digital data but also text, voice, image and facial expression data. - Deploy targeted digital advertising in real time.	Bank of Montreal (BMO) uses IBM Interact to analyse customer data across all channels and identify personalized product offerings. If a client has looked at mortgages on the BMO site and later calls the contact centre, IBM Interact prioritizes the list of available mortgage offers for the contact centre service agent, thus increasing the capabilities of the agents and facilitating more relevant conversations with customers.	(Davenport *et al.*, 2020)
Artificial Intelligence	- Make more intelligent, more intuitive and more automated data exploration processes. - Expedite customer segmentation. - Lead customization, and marketing element customization.		(Kumar, Ramachandran & Kumar, 2020).
Artificial Intelligence	- Help network operators to address areas that are new. - Correlate multiple data sources and find what is relevant. - Reveal inter-relationships and dependencies that were not previously identified.		(Kibria *et al.*, 2018).
Machine Learning	- Increases interactivity with users. - Provides custom information based on user interaction. - Keeps users personally involved. - Facilitates their intention of reuse. - Allows applications to serve and suggest the most appropriate content for users.	Sabadell Bank Spain offers video-enabled phone banking to answer customer questions.	(Cheng *et al.*, 2020) (Dauda & Lee, 2015)
Machine Learning	Random Forests (RF) is a machine learning technique for modelling classification problems. It is supported by an efficient computational algorithm for the analysis of large data sets.	The application of the RF rating system in the European banking system to create an early warning system for bank failures in Europe. A solid test for classification purposes, as this region is characterized by a significant disparity in financial institutions due to the specific macroeconomic characteristics of countries.	(Petropoulos *et al.*, 2020)

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Technology	Personalization	Example	Reference
Machine Learning	- Cleans up data, recognizes models to identify useful and applicable data, and integrates various databases.	Enables companies to automate the process of drawing structured and unstructured data from a variety of sources (digitization panels, social networks and e-commerce, sensors, devices, video/audio, networks, log files, transactional applications, websites, etc.)	(Kumar, Ramachandran & Kumar, 2020)
Machine Learning	- Studies complicated phenomena that evolve over time.		(Hagen *et al.*, 2020)
Recommender System	- Increases confidence in personalized recommendations generated through banking data in mobile recommendation systems.		(Gallego Vico *et al.*, 2012)
Recommender System	- Offers to the user the possibility of receiving personalized recommendations in constantly changing environments.	The mobile application recommends places that are already visited by users and where they paid with their credit card.	(Pimenidis, Polatidis, & Mouratidis, 2019)
Internet Of Things	- A Continuous communication in real time, from the customer to the machine, from the machine to the machine and from the company to the machine.	An ATM getting authorization from the bank for a cash withdrawal via IoT.	(Rust, 2020) (Huang & Rust 2021).
Internet Of Things	- Provides businesses and marketing strategists with opportunities to explore highly contextual and tailored approaches to consumers, particularly based on their past behaviours. -Expands communications and creates opportunities for companies to become more efficient, responsive and even more proactive, especially with regards to customer service.	- Helps the Internet to become more immersive and also facilitates the interaction and access for a wide range of devices, such as smartphones, cameras and surveillance sensors. - The ability of marketers to offer new solutions and improve communication with clients in a much broader way, regardless of contact points or stages of the customer's overall life cycle. - IoT can capture data on customers, thus providing a rich database for CRM systems.	(Lo & Campos 2018) (Kumar, Ramachandran & Kumar, 2020)
Blockchain	- Allows users not only to have the right to control their own data, but also to monitor all request operations for data audit and liability in case of dispute.	- A solution to the security problems of big data technology with immutability, security and traceability. - Blockchain can ensure the security of customer data on CRM systems and allowing it to directly deliver reward/loyalty points and personalized offers to clients, without any intermediation.	(Shi *et al.*, 2020) (Kumar, Ramachandran & Kumar, 2020)
Blockchain and Big Data	- Provides better targeting for digital marketing campaigns.	- Provides a reliable measure of marketing and advertising campaign performance, offering enormous benefits for digital marketing and email marketing, where tracking will help avoid fraud.	(Antoniadis, Kontsas, & Spinthiropoulos, 2019)
Blockchain and Big Data	- Can be combined with other technologies to create more meaningful impacts.	- Blockchain transactions can be used for Big Data analysis. In this sense, users can predict the potential development of business activities and create many new opportunities.	(Chang *et al.*, 2020)

From Table 1, it can be seen that, in the M-Banking context, Technology-enabled personalization (TEP) has become possible thanks to the following technologies: Artificial intelligence, machine learning, recommender systems, Internet of Things and blockchain. The physical dimensions of personalization of M-Banking services concern locations inferred from GPS, voices, facial expressions inferred from images and real-time interactions (video banking) through sensors and devices. The digital dimensions of personalization relate to banking data, such as demographics and operations, social networks, e-commerce and websites.

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Summary of Results on the Role of Personalization in Adopting Mobile Services

This section presents a synthesis of the main studied papers showing the different roles evoked for personalization in various contexts of e-services and mobile services. The studied corpus covered 26 journal articles published between 2005 and 2021. The first step of paper selection consisted of a search on Google Scholar using combinations of the following keywords: Personalization, Technology, Mobile services, Mobile applications, adoption factors, adoption intention, Use intention, Technology acceptance, UTAUT. The second step aimed to exclude papers not relevant to the studied field, based on the reading of abstracts.

Table 2. Summary of related works on the role of Personalization in e-services and mobile services adoption, contexts and technologies

Role of Persona-lization	Independent variable(s)	Dependent variable(s)	Context	Related Technologies	Author
Moderator	- Performance Expectancy - Effort Expectancy - Social Influence - Facilitating Conditions - Hedonic Motivation - Habit	- Continuous Use Intention	Mobile News Apps	Algorithms and machine learning	(Cheng *et al.*, 2020)
Moderator	- Information quality - System quality - Service quality	- Application satisfaction	Fashion Application	Fashion m-commerce apps	(Trivedi & Trivedi, 2018)
Moderator	- Performance Expectancy - Effort Expectancy - Social Influence - Facilitating Conditions - Motivation intention - Habit - Price value	- Behavioural intention	E-government services	Recommender systems	(Krishnaraju *et al.*, 2016)
Moderator	- Perceived usefulness - Perceived ease	- Customer satisfaction	Mobile Banking	Mobile Banking applications	(Albashrawi & Motiwalla, 2015)
Mediator	- Conversation/Conformity Orientation - Depressive Symptoms/Self-Esteem	- Direct Personalization of Conflict	Family Communication Patterns		(Curran & Allen, 2017)
Mediator	- Perceived effectiveness of privacy - Safe feature and psychological comfort with the application	- Perceived personalization benefits	Smartphone users	Mobile location tracking services	(Sutanto *et al.*, 2013)
Causal	- Personalization	- Continuous use intention	Mobile News Apps	Algorithms and machine learning	(Cheng *et al.*, 2020)
Causal	- Personalization	- Emotional experiences -Cognitive experiences	Omnichannel retail	-Mobile devices -Artificial intelligence	(Tyrväinen Karjaluoto & Saarijärvi, 2020)

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Role of Persona -lization	Independent variable(s)	Dependent variable(s)	Context	Related Technologies	Author
Causal	- Customers' Value for Online Personalization	- Use of online banking services	Online banking services		(Salem Baidoun & Walsh, 2019)
Causal	- Personalization	- E-satisfaction	Mobile Store	Mobile Store Features	(Alalwan *et al.*, 2019)
Causal	- Perceived personalization	- Brand attachment - Brand engagement	Social media		(Shanahan Tran & Taylor, 2019)
Causal	- Personalization level	- Electronic word of mouth - Perceived Trust	Mobile Banking	Mobile banking service applications	(Zalloum, Alghadeer & Nusairat, 2019)
Causal	- Information Personalization - Presentation Personalization - Navigation Personalization	- Cognitive (utilitarian) Experience - Hedonic Experience	E-commerce website		(Desai, 2019)
Causal	- Personalization	- Customer Satisfaction	Banking Sector		(Altobishi *et al.*, 2018)
Causal	- Personalization	- Intention to use mobile marketing services	Mobile marketing services		(Saeed & Bekhet, 2018)
Causal	- Personalization	- Attitude - Emotional value	M-advertisement technology adoption		(Haq & Ghouri, 2018)
Causal	- Personalization	- Performance expectancy - Effort expectancy	E-banking usage		(Wang, Cho & Denton, 2017)
Causal	- Personalization	- Behavioural intention	Mobile Internet		(Islam, 2017)
Causal	- Website personalization Technology sourcing	- Social media performance - Sales performance	social media marketing	-Artificial neural network -Genetic algorithms	(Oberoi, Patel & Haon, 2017)
Causal	- Personalization	- Perceived Value - Perceived Ease of Use - Perceived Usefulness - Attitude Towards Use - Behavioural Intention to use	Mobile Services Adoption		(Asif & Krogstie, 2013)
Causal	- Personalization	- Trust - Adoption Intention	Mobile health		(Guo & Wang, 2012)
Causal	- Personalization	- Perceived Benefits of Info Disclosure - Perceived Risks of Info Disclosure	Location-aware marketing	GPS	(Xu *et al.*, 2011)
Causal	- Personalization	- Mobile Banking Services Adoption	Mobile Banking		(Saeed, 2011)
Causal	- Personalization	- Intention to adopt - Privacy concerns	U-commerce	-Radio frequency identification (RFID) -GPS -Sensor networks	(Sheng, Nah & Siau, 2008)
Causal	- Value for personalization	- Likelihood of using online personalization services	Online Consumer	-Tracking technologies, e.g., cookies, clear gifs	(Chellappa & Sin, 2005)

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Role of Persona -lization	Independent variable(s)	Dependent variable(s)	Context	Related Technologies	Author
Causal	- Personalization	- Overall service quality - Customer satisfaction	online shopping		(Lee & Lin, 2005)

The results above argue that previous publications are not unanimous as to the nature of the personalization role in the context of mobile services. Table 2 shows a set of studies that confirm the moderating or mediating effect of personalization on adoption factors and use intention. Moreover, Table 2 presents a second set of papers that confirm that personalization rather exerts a causal relationship on the adoption factors of technology-based services. Among the 26 papers presented in Table 2, only six papers treated the context of Mobile banking and this confirms the scarcity of studies that focused on this context. A deep analysis of studies conducted in the context of mobile banking shows that only one research work confirmed the moderator role on customer satisfaction (Albashrawi & Motiwalla, 2015), and that five studies confirmed the causal role of personalization on electronic word of mouth, perceived trust, customer satisfaction, intention to use mobile marketing services, perceived value, perceived ease of use, perceived usefulness, attitude towards use, behavioural intention to use, and mobile banking services adoption (Altobishi, Erboz & Podruzsik, 2018; Asif & Krogstie, 2013; Saeed, 2011; Saeed & Bekhet, 2018; Zalloum, Alghadeer & Nusairat, 2019).

Personalization and Adoption Factors of Mobile Banking Services

The intensive transformation of product and service through the integration of technologies such as AI, Big Data, and Blockchain, has caught the attention of researchers and has given rise to a variety of technology adoption models (Hmoud & Varallyai, 2020). Many researchers have studied different aspects of the acceptance of new technologies from a variety of theoretical perspectives, such as the Theory of Planned Behaviour (TPB) (Ajzen, 1985), the Technology Acceptance Model (TAM) (Davis, 1989), Diffusion of Innovation Theory (Rogers, 1995), Unified Technology Acceptance and Utilization Theory (UTAUT) (Venkatesh, Ramesh & Massey, 2003) and UTAUT2 theory (Venkatesh, Thong & Xu, 2012).

Widuri, Kholil & Nurbani (2020) found that the UTAUT theory is the most comprehensive, and can describe in detail the context of technologies' acceptance compared to other alternative theories or models. Moreover, this theory demonstrates good generalization and high explanatory power in information systems (IS) research, but is rarely applied to the context of mobile banking (Albashrawi *et al.*, 2017).

UTAUT was developed by Venkatesh, Ramesh & Massey (2003) to study the use of technology in an organizational context by proposing four key concepts as direct determinants of

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behavioural intention and utilization behaviour, namely: Effort Expectancy (EE); Performance Expectancy (PE); Facilitating Conditions (FC); and Social Influence (SI). Venkatesh, Thong & Xu (2012) added Hedonic Motivation (HM), Price Value (PV) and Habit (HT) as technology adoption factors. These authors also introduced concepts of age, gender and experience as moderating factors in the same model.

Personalization and effort expectancy

Effort expectancy is the degree of ease associated with consumers using technology (Venkatesh, Thong & Xu, 2012). The results of Alalwan, Dwivedi & Rana (2017) and Albashrawi *et al.* (2017) show that the effort expectation positively influences M-Banking adoption intention.

According to Wang, Cho & Denton (2017), personalization has an impact on the effort expectancy for online banking services. Personalization increases perceptions of ease of use, making the delivery of electronic banking services more effective and efficient.

Blom & Monk (2003) mentioned that it may seem odd that a non-functional change such as appearance customization could affect perceived ease of use. However, there are attributes related to this feeling that can be taken into account by making changes to the appearance.

Due to the potential of recommender systems, effort expectancy will have a stronger impact on the intention to use e-government services with a higher level of web personalization (Krishnaraju, & Sugumaran, 2016). Similarly, with the use of the banking referral system, the interaction becomes clearer and more understandable, allowing the user to choose an appropriate banking service more easily (Asosheha, Bagherpour & Yahyapour, 2008). Indeed, the higher the convenience felt by customers when using the M-Banking app, the more customers are interested in using the app (Hariyanti, Hidayatullah & Prasetya, 2020).

The results of Cheng *et al.* (2020) showed that personalization had no discernible moderating impact on the relationship between effort expectancy and continued use intention of mobile news apps. Furthermore, Merhi, Hone & Tarhini (2019) showed that effort expectancy was not a significant predictor and that the negative effect of not knowing a particular system on user intent could be managed by organizing training sessions or online modules.

Based on the previous developments, the following hypotheses are stated:

H1-1: Personalization positively influences effort expectation of using M-Banking services.

H1-2: Effort expectation positively influences M-Banking adoption intention.

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Personalization and performance expectancy

Performance expectancy is defined as the degree to which the use of a technology will provide benefits to consumers in performing certain activities (Venkatesh, Thong & Xu, 2012). The results of Alalwan, Dwivedi & Rana (2017), Albashrawi *et al.* (2017), and Phan *et al.* (2020) show that performance expectancy positively influences the intention to adopt M-Banking. Indeed, the higher the profits obtained by customers when using the M-Banking application, the more the customer is interested in using it (Hariyanti, Hidayatullah & Prasetya, 2020). On the other hand, the study conducted by Merhi, Hone & Tarhini (2019) shows that performance expectancy is not a predictor influencing the intention to adopt M-Banking.

Personalization has a great impact on performance expectancy and on responses from customers who are either inexperienced with e-banking in general, or familiar with a completely different one. Wang, Cho & Denton (2017) indicate that personalization leads them to find more utility in their experience. In addition, personalization helps to reduce the time needed to complete tasks, improve efficiency and offer the desired information in the right form to targeted users (Cheng *et al.*, 2020).

Compared to traditional personalization in bricks-and-mortar stores, customers expect TEP to help them find products faster and that meet their current needs, through a simplified shopping experience in a short period of time (Riegger *et al.*, 2021). Similarly, Asosheha, Bagherpour & Yahyapour (2008) admitted that the use of a banking recommendation system has an effect on the increase of performance in the execution of banking tasks.

Based on the previous developments, the following hypotheses are stated:

H2-1: Personalization positively influences the performance expectancy of using M-Banking services.

H2-2: Performance expectancy positively influences M-Banking adoption intention.

Personalization and facilitating conditions

Facilitating conditions refer to consumers' perception of the resources and available support to perform behaviour (Venkatesh, Ramesh & Massey, 2003). The study conducted by Baabdullah *et al.* (2019) shows that facilitating conditions positively influence the intention to adopt M-Banking. This means that the use of mobile banking services requires a certain level of knowledge and skills (Alalwan, Dwivedi & Rana, 2017). In the same way, Venkatesh, Thong & Xu (2012) conclude that the consumer who has access to a favourable set of facilitating conditions is more likely to have a higher intention to use a technology, and that gender and age moderate the effect of facilitating conditions on behavioural intention.

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According to research by Albashrawi *et al.* (2017) and Boonsiritomachai & Pitchayadejanant (2017), facilitating conditions have no effect on the intention to use M-Banking. This shows that the organizational and technical infrastructure, such as unstable Internet networks and smartphones that support the M-Banking application, does not increase customers' interest to use it (Hariyanti, Hidayatullah & Prasetya, 2020).

According to Cheng *et al.* (2020), Personalization has no discernible moderating impact on the relationship between facilitating conditions and intention to use e-government services.

It is important that users have a sense of exclusivity of the service and that their intentions are properly recognized if they use personalized news applications. Other aspects of enabling conditions, such as native language support or helping users with the ability to translate content from one language to another, may also lead to a continued use intent of a personalized news app (Cheng *et al.*, 2020).

The previous developments make it possible to state the following hypotheses:

H3-1: Personalization positively influences the conditions for facilitating the use of M-Banking services.

H3-2: The facilitation conditions positively influence the intention to adopt M-Banking.

H3-3: Age plays a moderating role between the facilitating conditions and the intention to adopt M-Banking.

H3-4: Gender plays a moderating role between facilitating conditions and M-Banking adoption intention.

Personalization and social influence

Social influence is the extent to which consumers perceive that important people (e.g., family and friends) believe they should use a particular technology (Venkatesh, Thong & Xu, 2012). According to Albashrawi *et al.* (2017), Merhi, Hone & Tarhini (2019) and Phan *et al.* (2020) social influence has a positive impact on the intention to adopt M-Banking. On the other hand, in some studies social influence does not have a significant effect on the intention to adopt M-Banking. This means that bank customers are not influenced by the recommendations and attitudes of their reference groups to formulate their intention to adopt the technology (Alalwan, Dwivedi & Rana, 2017; Baabdullah *et al.*, 2019; Hariyanti, Hidayatullah & Prasetya, 2020).

Blom & Monk (2003) admitted that a major cause of personalized services adoption was the use of the service by several friends. Indeed, personalization had the ability to identify people with similar preferences and tastes on the same social network. However, Chang *et al.* (2020)

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argued that personalization does not moderate the relationship between social influence and intention to continued use of mobile apps.

The previous developments make it possible to state the following hypotheses:

H4-1: Personalization positively impacts the social influence of using M-Banking services.

H4-2: Social influence positively impacts the intention to adopt M-Banking.

Personalization and hedonic motivation

Hedonic motivation is defined as the fun or pleasure derived from using a technology, and it has been shown to play an important role in determining technology acceptance and use (Brown & Venkatesh, 2005). According to Venkatesh, Thong & Xu (2012), Hedonic Motivation is an essential determinant of behavioural intention and is a more important factor than performance expectation. They suggest that, in a context of mainstream computing use, utilitarian and hedonic advantages are important elements of technology usage.

In the specific context of Mobile banking, several researchers showed that Hedonic Motivation was empirically found as an important factor influencing M-Banking adoption intention (Baabdullah *et al.*, 2019; Boonsiritomachai & Pitchayadejanant 2017; Hariyanti, Hidayatullah & Prasetya, 2020; Merhi, Hone & Tarhini, 2019). Bank customers perceive joy, entertainment and pleasure when using mobile applications (Alalwan, Dwivedi & Rana, 2017). According to Venkatesh, Ramesh & Massey (2003), the effect of hedonic motivation on behavioural intention was stronger for younger men with less experience with technology.

Sung, Grinter & Christensen (2009) suggested that personalization helps technology users feel increased attachment to the product. This can help to accelerate emotional engagement with its use. Personalization features must be effective in terms of their ability to elicit emotions. Indeed, comments regarding reaction to the personalized device often referred to feelings of amusement or enjoyment. This explains why several members of the focus groups resorted to personalization to adapt to their current emotional states. Personalization can therefore be seen as a means of regulating current feelings (Blom & Monk, 2003).

Riegger *et al.* (2021) found that consumers perceive intrinsic satisfaction from TEP in stores, particularly due to the positive emotions associated with personal recognition and affirmation. Moreover, Krishnaraju, Mathew & Sugumaran (2016) admit that, with a higher level of web personalization based on a recommendation system, hedonic motivation will have a stronger impact on the intention to use e-government services. On the other hand, other research states that personalization does not influence the relationship between hedonic motivation and intention to continue using mobile news apps (Cheng *et al.*, 2020; Haq & Ghouri, 2018).

Based on the previous developments, the following hypotheses are stated:

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H5-1: Personalization positively influences the hedonic motivation to use M-Banking services.

H5-2: Hedonic motivation positively influences the intention to adopt M-Banking.

H5-3: Age plays a moderating role between hedonic motivation and intention to adopt M-Banking.

H5-4: Gender plays a moderating role between hedonic motivation and intention to adopt M-Banking.

Personalization and price value

Dodds, Monroe & Grewal (1991) defined price value as consumers' cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them. Venkatesh, Thong & Xu (2012) determined that price value is positive when the benefits of using a technology are perceived to outweigh the monetary cost. Moreover, aged women, more than others, emphasize technology's price. This suggests that aged women are more sensitive to the prices of products and services and will be more cost-conscious than aged men, due to their social role as guardians of family expenses.

In the banking context, price value positively influences M-Banking adoption intention (Hariyanti, Hidayatullah & Prasetya, 2020). Indeed, the improvement of the price value could be achieved by convincing customers that the adoption of M-Banking service will lead to greater financial and time savings, and increase the service price value. So, instead of wasting time and money to visit banks, users can directly monitor their financial issues from any location (Baabdullah *et al.*, 2019). Price value was not revealed to be a significant predictor in some previous studies (Merhi, Hone & Tarhini, 2019). This result could be related to technology that requires additional hardware or usage costs. Moreover, the low importance of price value could be attributed to the low or no cost required using mobile banking services.

According to Tyrväinen, Karjaluoto & Saarijärvi (2020), personalization reduced customer searches and the cost's evaluation, and this increased their loyalty. Rust (2020) admitted that the low cost of personalization in the information service environment makes personalization more feasible. The low cost of personalization can in many cases affect a user's desire to personalize, especially for younger groups (Blom & Monk, 2003).

The previous developments make it possible to state the following hypotheses:

H6-1: Personalization positively influences the value of the price of using M-Banking services.

H6-2: Price value positively influences M-Banking adoption intention.

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H6-3: Age plays a moderating role between the price value and the intention to adopt M-Banking.

H6-4: Gender plays a moderating role between the price value and the intention to adopt M-Banking.

Personalization and habit

Habit is defined as the extent to which people tend to perform behaviours automatically because of learning (Limayem, Hirt & Cheung, 2007). Baabdullah *et al.* (2019) admitted that habit positively improves the use of M-Banking. This proves that the more the customer has become familiar with using the M-Banking application, the more he or she is interested in using the application. However, some customers still find difficulties in using M-Banking to transact, so it takes more time to be habituated to using M-Banking (Hariyanti, Hidayatullah & Prasetya, 2020). Furthermore, the impact of habit on behaviour differs by age and gender. Indeed, as age increases, gender differences in experiential learning of technologies become more pronounced (Venkatesh, Thong & Xu, 2012).

Some researchers confirm that website personalization does not have a moderating effect in the relationship between habit and behavioural intention (Krishnaraju, Mathew & Sugumaran, 2016). Other more recent studies admit the existence of this moderating role in the case of mobile applications. The advantages of utility and personalization features help to reinforce the effect of habit on using new apps, especially when users are happy with their experiences of getting preferred content (Cheng *et al.*, 2020).

The previous developments make it possible to state the following hypotheses:

H7-1: Personalization positively influences the habit of using M-Banking services.

H7-2: Habit positively influences the intention to adopt M-Banking.

H7-3: Age plays a moderating role between habit and intention to adopt M-Banking.

H7-4: Gender plays a moderating role between habit and intention to adopt M-Banking.

Direct Effect of Personalization on Intent to Use

Personalization has a positive impact on behavioural intention in the case of mobile Internet; it was found to be an important factor alongside the existing factors of the UTAUT model (Islam, 2017). In the case of mobile services, results are controversial: some studies (Saeed & Bekhet, 2018) have found personalization to be an insignificant predictor of adoption intention for M-Marketing services, while Salem, Baidoun & Walsh (2019) admitted that the customer value for online personalization has a causal impact on the use of online banking

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services. Indeed, in addition to the ad hoc information obtained during registration, a process of customization based on algorithms and machine learning allows mobile applications to suggest the most suitable content to users, this may influence their usage intentions (Cheng *et al.*, 2020). The previous developments argue the following hypothesis:

H8: Personalization positively influences the intention to use M-Banking services.

Impact of Personalization on Mobile Banking Adoption Drivers: Conceptual Model

The summary of prior work on Technology-enabled Personalization (Table 1) identified the main technologies that support the personalization strategy of mobile banking services. In addition, the synthesis presented in Table 2 outlines the controversies regarding the causal, moderating or mediating role of personalization of mobile services' adoption. Moreover, the literature review detailed above shed light on a set of adoption factors, which are evoked in the context of mobile banking, namely: Effort Expectancy (EE); Performance Expectancy (PE); Facilitating Conditions (FC); Social Influence (SI); Hedonic Motivation (HM); Price Value (PV); and Habit (HT). Based on these previous developments, this research proposes a conceptual model that illustrates the causal link between personalization and adoption factors of mobile banking services (Figure 1). Furthermore, the conceptual model generated in this research outlines the mediating role of adoption factors between personalization and the intention to adopt mobile banking services. Age and gender are argued as factors that moderate the impact of adoption factors and the intention to adopt mobile banking services.

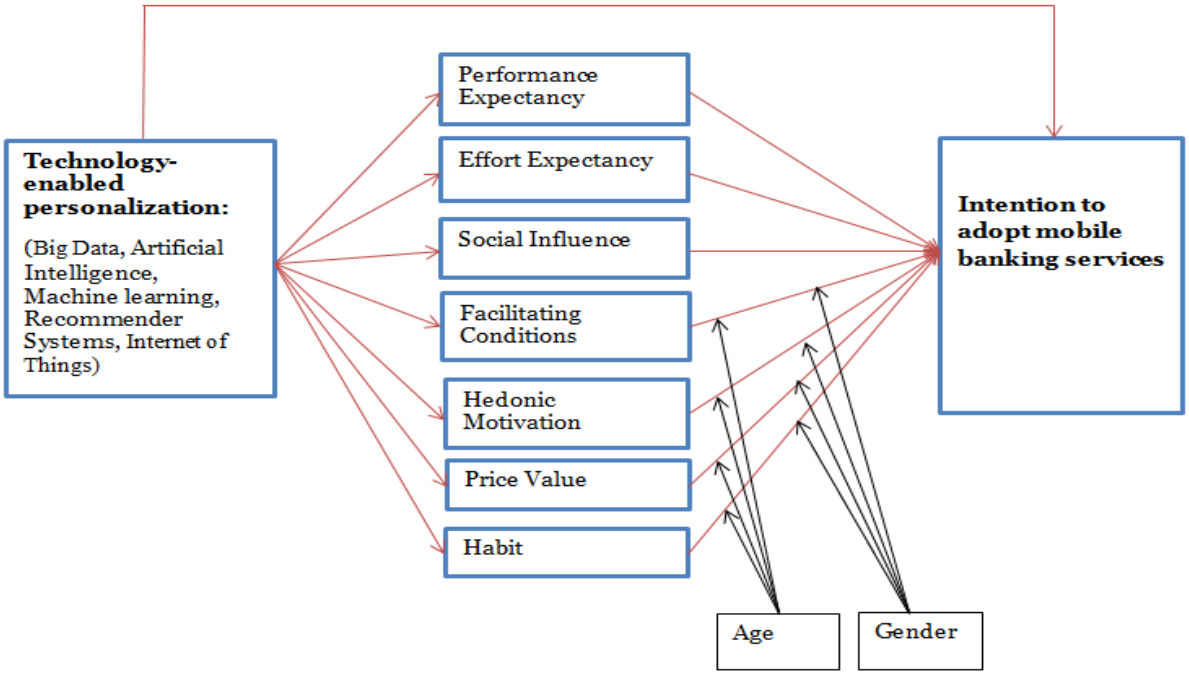

Figure 1. Impact of personalization on mobile banking adoption drivers: conceptual model

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This conceptual model orients future studies regarding potential methods for empirical validation. Experimentation is an appropriate method that could be used to confirm the causal role of personalization on the factors of adoption of mobile services. In addition, Clustering and Text Mining techniques, such as Topic Modelling or Sentiment Analysis, are relevant tools analysing large databases of comments on M-Banking services that customers post on social networks or send by email (Benslama & Jallouli 2020; Chebil *et al.*, 2021). The results of such applications help to compare the adoption factors and the intention to use M-Banking systems for each cluster of users and to guide banks making better marketing decisions. Indeed, emerging technologies enable the bank to personalize system functionalities based on contextual variables from experiences and the demographics of each user group, such as gender, age, education, and income information (Motiwalla, Albashrawi & Kartal, 2019).

Conclusions and Recommendations

Previous research and modelling efforts highlight the considerable role of personalization across new-age technologies, for guiding and implementing segmentation, targeting and positioning strategies. Indeed, each customer admits one or more specific criteria that distinguish him/her; moreover his/her behaviour is not always static, and it can change over time and according to the context. In this regard, technologies such as Artificial Intelligence, Machine Learning, Recommender Systems, Big Data, Internet of Things and Blockchain can adapt to this regular change and offer individualized and personalized services in real time. Based on this literature review, and on previous research in the specific context of mobile banking services, this paper has proposed a conceptual model illustrating the impact of technology-enabled personalization on the different factors of intention to adopt mobile banking services, namely: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Motivation Intention, Habit and Price value. The direct effect between personalization and intention to adopt mobile banking services was also argued.

This analysis expands knowledge in the field of personalization, especially with regard to Mobile Banking. The literature review synthesis presented in this paper is an important piece of research that intends to find future empirical studies in order to validate the conceptual model illustrating the impact of personalization on the adoption factors of mobile services.

Finally, this paper suggests that technology-enabled personalization (TEP) is taking on new forms and benefits in the case of mobile banking services, hence the importance of deepening the investigation around its levers and barriers by inviting innovative methods, such as Clustering, Text Mining, Topic Modelling and Sentiment Analysis. Such methods allow processing a large volume of customer comments, experiences and reactions in real time, and orient marketing decisions in terms of personalization based on technologies.

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Volatility Behaviour of Bitcoin as a Digital Asset

Evidence of Shock Transmission Dynamics from the South African Financial Markets

Thabo J. Gopane
University of Johannesburg

Abstract: The objective of this study is to use the South African financial markets (Johannesburg Stock Exchange or JSE and USD/ZAR) as a case study to understand the volatility spillover dynamics of Bitcoin as a digital asset. Methodologically, the study applies the exponential generalized autoregressive conditional heteroskedastic (EGARCH) model, followed by a robustness check by applying the time-varying conditional correlation multivariate GARCH (VCC-MGARCH) model. The study utilizes the data set for the period 2011 to 2019, a period before the COVID-19 pandemic. The research outcome revealed three interesting observations. First, Bitcoin and the South African stock market are independent of each other. Second, there is a bidirectional shock transmission between Bitcoin and USD/ZAR in the mean returns only, but not variance. Lastly, results confirm the existence of a bidirectional volatility spillover in both the mean and variance between the JSE stock market and the USD/ZAR market. The study outcome should enlighten investors who may want to consider Bitcoin as a diversifier in their investment and portfolio strategies.

Keywords: Bitcoin, cryptocurrency, volatility spillover, foreign exchange, digital asset.

Introduction

The popularity of cryptocurrency in South Africa grows in tandem with global market trends. However, its intermarket relationship with local financial markets is yet to be understood, and the current paper contributes towards closing this gap. The goal of the study is to investigate the dynamic interactions of Bitcoin cryptocurrency in the South African financial markets. In particular, the research should answer the question of whether there is volatility spillover between Bitcoin as a digital asset and the Johannesburg Stock Exchange (JSE) listed equity market, as well as the foreign exchange market of the US Dollar relative to the South African

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Rand (USD/ZAR). Bitcoin is the first and most dominant cryptocurrency with a market share of around 50% in April 2021. Regarding the ongoing market activity in cryptocurrency, the number of alternatives to Bitcoin (known as altcoins) have mushroomed to more than 5,000 and counting. Bitcoin is said to be the speediest asset to cross-over the market capitalization line of USD 1 trillion within 12 years of its existence compared to Google (21 years), Amazon (24 years), Apple (42 years), and Microsoft (44 years).

Regarding its consumer usage, even though it fails the fundamental economics definition of money (Yermack, 2015), Bitcoin was designed to be a virtual currency (Nakamoto, 2008) and to operate as an alternative to conventional in-use money. However, unlike fiat currency (the traditional money in notes and coins), a cryptocurrency payment system is designed to operate digitally through cryptography validation and free of third-party trusted authority like a central bank. Bitcoin also belongs to a family of digital currencies, much like central bank reserves, or the topical concept of Central Bank Digital Currency (Bindseil, 2019; Gopane, 2019a). In general, Bitcoin as cryptocurrency is characterized by pseudo-anonymity, independence, and double-spending protection, along with uneven recognition by national authorities around the world (Lansky, 2018). Further details on Bitcoin properties, including its operational design and historical developments, are discussed elsewhere (Wolfson, 2015; Gopane, 2019b). Users of cryptocurrency, especially early patrons, are said to be influenced by a prospecting instinct for viable alternatives to the increasingly crisis-susceptible financial markets (Danielsson, Valenzuela & Zer, 2018). More notably, investors' curiosity in Bitcoin digital currency is seemingly induced by its nature of speculative investment (Yermack, 2015).

There is ongoing academic research in different dimensions of Bitcoin cryptocurrency, including currency properties (Ali *et al.*, 2014; Bouoiyour & Selmi, 2015), price evaluation (Dyhrberg, 2016), as well as portfolio management (Brière, Oosterlinck & Szafarz, 2015), to mention a few. The focus of the current study is to investigate the less studied case of Bitcoin volatility spillover dynamics in an emerging market like South Africa.

The Nobel Laureate, Robert F. Engle III, is a pioneer of the GARCH (Generalized Autoregressive Conditional Heteroskedastic) econometric model, which has become a work horse for volatility studies. Engle (1982) stressed the importance of understanding volatility spillover dynamics for asset price determination, risk analysis, and portfolio diversification. Since the virtual currency market is relatively new, the study of volatility dynamics for Bitcoin will have a significant value-add if extended to all emerging markets, including Africa, in today's integrated financial markets.

Research on volatility spillover, asset and market relatedness (Carpenter, 2016; Trabelsi, 2018; Corbet *et al.*, 2018; Baumöhl, 2019) has been conducted in different economies in

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Europe, North America, and Asia, but little has been researched in Africa, and with varying results. In general, unresolved questions call for deepening and broadening of empirical work. The current paper contributes to correcting this imbalance in Bitcoin and financial assets research. At present, we are unaware of a similar study that examines the volatility spillover of Bitcoin as a digital asset in the South African financial markets.

In addition, and by way of further motivation, Figure 1 plots (on the vertical left scale) the Google search index as a proxy of general user interest in Bitcoin (a form of connectedness). The graph reveals strong harmony in patterns of Bitcoin user interest for South Africa compared with the rest of the world. The secondary vertical axis (on right) measures the price of Bitcoin in USD, and its historical trend displays a lead-lag relationship with the cryptocurrency user-interest. Overall, the graphs provide *prima facie* evidence that South Africa is connected in some way to the global Bitcoin market. This observation inspires further analytical investigation in the context of the current study.

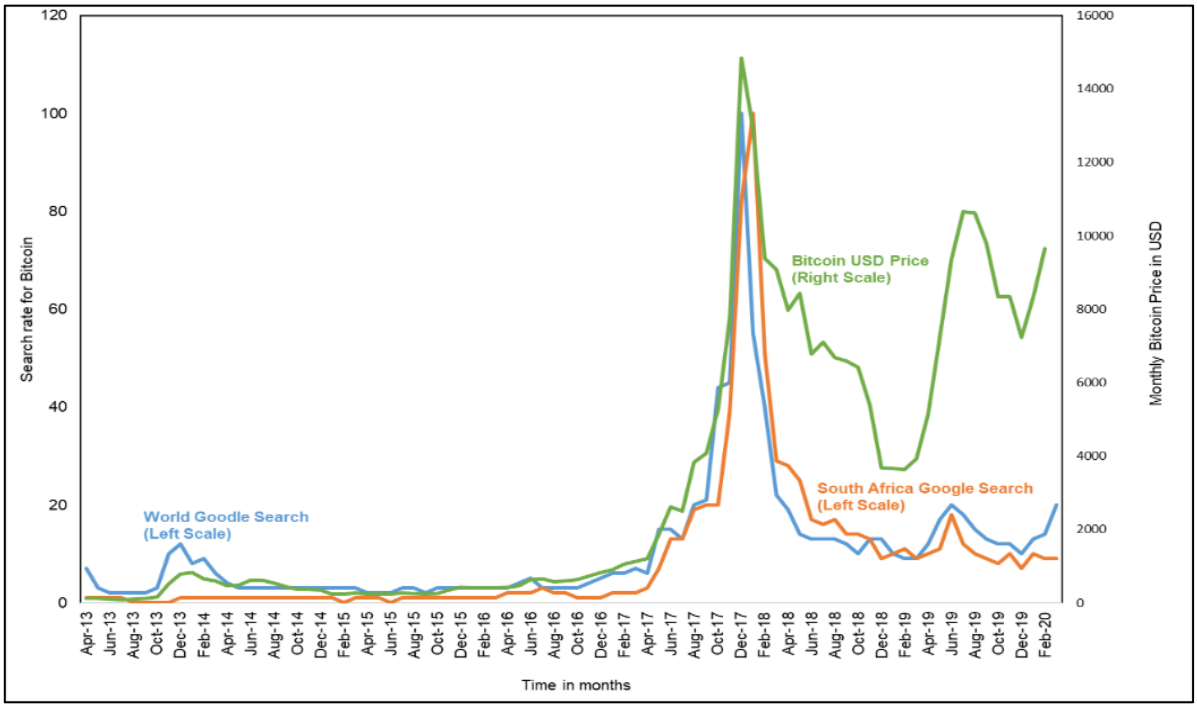

Figure 1. Google's Bitcoin Search Index (Left Scale) for the World and South Africa, and Monthly Bitcoin Price in USD (Right Scale). ***Source: Author's own graphics.***

There is other supportive evidence on the adoption of cryptocurrency in South Africa and its connectedness to global markets. Jankeeparsad and Tewari (2018) have empirically examined the end user take-up of cryptocurrency and found that perceived usefulness, as well as availability of facilitating resources, were some of the important determinants of Bitcoin take-up adoption in South Africa. The South African government (Intergovernmental Fintech Working Group, 2021) estimates that daily trading values of crypto assets exceed two billion South African Rands. Unlike in other countries (such as Algeria, Egypt, and Morocco) where

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cryptocurrency is banned, the South African authorities have not imposed any direct restrictive usage, and therefore cryptocurrency adoption can grow in tandem with market forces. However, as a member of the Financial Action Task Force (FATF), South Africa is expected to introduce some regulatory framework for cryptocurrency; and they have announced the initiation of this project in April 2021 (Intergovernmental Fintech Working Group, 2021).

The rest of the paper is organized and sequenced into the following sections: literature review, methodology including econometric methods and data description, empirical results and interpretation, discussion of results, as well as conclusion and policy implications of the research outcomes.

Literature Review

It is an accepted position in financial economics that knowledge of asset volatility is critical in today's open economies (Bouri *et al.*, 2018), integrated financial markets (Obadan, 2006), digitalization (IMF, 2018; OECD, 2019), and globalization (Boshoff & Fourie, 2017). The literature has shown that there is increased propagation and transmission of economic shocks during financial crises in South Africa (Boshoff, 2006) and other countries (Kaul & Sapp, 2006; Danielsson, Valenzuela & Zer, 2018). Also, it is not surprising that established models (Vasicek, 1977; Cox, Ingersoll & Ross, 1985; Hull & White, 1990) of sensitive monetary variables, such as interest rates, include volatility measure as an important input in their design.

Since its inception in 2009, Bitcoin has attracted studies in different dimensions of academic research. For instance, there is antagonistic research on the politics of Bitcoin, questioning the claims of trust-free money (Dodd, 2017) and critiquing its ethnography (Maddox *et al.*, 2016). Regarding general economic matters, studies evaluate Bitcoin's monetary policy connectedness (Blundell-Wignall, 2014; European Central Bank, 2015) owing to its potentially disruptive nature in financial regulatory systems (Financial Action Task Force on Money Laundering, 2015). Also, economists became equally interested in Bitcoin, partly due to its volatile behaviour (Baek & Elbeck, 2015) and to interrogate its relatedness to conventional financial markets. This line of research sought to find answers to questions related to Bitcoin's potential role in risk hedging (Bouri *et al.*, 2017), speculative investment (Baek & Elbeck, 2015), portfolio diversification (Brière, Oosterlinck & Szafarz, 2015; Carpenter, 2016), or asset selection and allocation (Platanakis & Urquhart, 2020). The current study extends the critical research of volatility studies to emerging markets where Bitcoin has shown visible expansion (Bouri *et al.*, 2018), but in which empirical volatility studies lag behind, especially in Africa. Economists express divergent views on the financial classification of Bitcoin, that is, whether

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Bitcoin is currency, commodity, synthetic commodity or gold (Selgin, 2015). For instance, some see Bitcoin as a hybrid between precious metals and fiat currency (Baur, Dimpfl & Kuck, 2018), or between gold and dollar (Dyhrberg, 2016), while others maintain that Bitcoin is not a currency (Yermack, 2015) but an asset (Smith, 2016). The current study follows the latter definition and takes this a step further in Dyhrberg's (2016) perspective, who conceived of Bitcoin as a digital asset much like gold. For this reason, and similar to Smith (2016) and Gopane (2019b), this paper will compare Bitcoin's product price with its (cross-rate) exchange rate. Further details are discussed in the methodology section.

A number of studies have investigated Bitcoin's volatility spillover dynamics in relation to stock market, foreign exchange, commodities, and against its fellow cryptocurrencies. Although most findings (Carpenter, 2016; Trabelsi, 2018; Corbet *et al.*, 2018) declare Bitcoin independent of financial markets, this is not conclusive, since there are some contradictory results, like those of Baumöhl (2019), among others. Brière, Oosterlinck & Szafarz (2015) examined cryptocurrencies' relationships with other assets (bonds, shares, currency, commodities, hedge funds, real estate) for weekly data from 2010–2013 and found low correlations. A similar study in Ireland by Corbet et al. (2018) also concluded that cryptocurrencies are rather isolated from the other financial markets. In a broad scope of asset classes, Trabelsi (2018) explored the subject of volatility spillover among cryptocurrencies and other actively traded asset classes and found no significant spillover effects. Nevertheless, in the Slovakian context, Baumöhl (2019) examined the connectedness of cryptocurrencies in relation to foreign exchange markets and observed a link between the two markets. The moral of the story is that the breadth and depth of cryptocurrency knowledge is still a work in progress and, more importantly, its inter-market behaviour and stylized facts are far from being a closed chapter (Gozgor *et al.*, 2019; Zeng, Yang & Shen, 2020; Wang *et al.*, 2021; Kayal & Rohilla, 2021; Zhao, 2022). The current study advances the ongoing research into the under-studied emerging market of South Africa.

Methodology

The goal of the model design in this study is to conduct an empirical enquiry on whether Bitcoin cryptocurrency has a volatility spillover relationship with JSE stock and foreign exchange (USD/ZAR) markets. The analysis will follow a two-step econometric procedure of univariate modelling explained within the current section followed by a robust check of results with a multivariate time series model discussed under the section on empirical results.

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Economic Model

In the first step of the two-stage econometric procedure, a GARCH (1, 1) model (see Equation Box 1) is estimated with three replications for each of the log returns of stock, Bitcoin, and USD/ZAR exchange rate. On each occasion, a series of standardized residuals is retrieved to be used as input in the next stage.

Equation Box 1: Empirical Modelling — Stage 1	
GARCH (1, 1)	$y_t = cy_{t-1} + \varepsilon_t, \ \ \forall\, t = 1, 2, 3 \ldots N$ $where \quad \varepsilon_t \sim iid(0, h_t)$ $\log h_t = \omega + \ a\varepsilon_t^2 + b\log h_{t-1}$
GARCH (1, 1) is represented by the above equations together. The first expression is the mean equation, where y_t represents returns, while ε_t is the error term. The second equation provides the variance estimation and h_t captures the variance innovations. The parameters, a, b, c and ω are estimated in this model. Further interpretation and intuition are given in the text.	

The second stage implements the main econometric model, EGARCH. The EGARCH model was proposed by Nelson (1991) as an innovation of and extension to the GARCH family, following the pioneering foundations of Engle (1982) and Bollerslev (1986). This model has important advantages that makes it a preferred analytical model for the current study. In addition to its attractive parsimony, EGARCH captures the usual *stylized facts* of financial returns (Enders, 2003) such as volatility clustering, fat-tailedness, leverage, as well as leptokurtic distribution, and, in particular, it relaxes the restriction of symmetry in the basic GARCH (1, 1) model. More specifically and for the benefit of the current study, EGARCH comes with a built-in capacity to guarantee the non-negativity condition of variance. Nelson's (1991) EGARCH (1, 1) model is presented in the framework of two equations, (1) and (2):

$$y_t = \phi y_{t-1} + \delta_1 x_{1t} + \delta_2 x_{2t} + \varepsilon_t, \ \ \forall\, t = 1, 2, 3 \ldots N \tag{1}$$

$$where \quad \varepsilon_t \sim N(0, h_t)$$

$$\log h_t = \omega + \ \alpha|\eta_{t-1}| + \gamma\eta_{t-1} + \beta\log h_{t-1} + \ \lambda_1 x_{1t} + \lambda_2 \, x_{2t} \tag{2}$$

$$where \ \ \eta_t = \frac{\varepsilon_t}{\sqrt{h_t}} \quad \text{and} \quad \eta_t \ \sim \ iid\,(0, \omega)$$

The first expression in (1) is the mean equation, where y represents returns calculated as the first log difference of the price data, $\ln\left(\frac{P_t}{P_{t-1}}\right)$, for each of the time series, namely, implied Bitcoin exchange rate, JSE All Share Index, and USD/ZAR foreign exchange rate. The regressors, x_1 and x_2, are residuals from the GARCH (1, 1) model computed in the first stage (Equation Box 1). The error terms (ε) are assumed to follow a normal distribution. In Equation

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(2), the variable h is the conditional variance. In both equations, the subscript t represents time in days, while the parameters to be estimated are $\alpha, \beta, \gamma, \delta, \eta, \lambda, \phi$ and ω.

A methodological framework of using two-step econometric modelling to examine shock transmission is a known procedure with theoretical motivation (Sefcik & Thompson, 1986), and widespread empirical application. For instance, Boshoff (2006) employed a similar framework to investigate the transmission of imported financial crises to South Africa. A similar model design for related empirical investigation was previously employed by several researchers, including, Hamao, Masulis & Ng (1990), Theodossiou & Lee (1993), Jebran & Iqbal (2016), and Jebran (2018), among others.

Data Characteristics

The empirical analysis was conducted using secondary data for three variables, namely, JSE All Share Index, USD/ZAR, and Bitcoin exchange rates. This study adopts a digital asset definition of Bitcoin exchange rate as elaborated in Smith (2016) and applied in Gopane (2019b). In this context, Bitcoin (much like gold) prices quoted in trading platforms and valued in diverse currencies like the USD, Euro, and British pound sterling (*inter alia*) are conceived as asset prices, and not exchange rates. Therefore, in order to derive the implied exchange rate of Bitcoin, we choose a triangle of stable currencies, USD, and Euro. So, to obtain the implied Bitcoin exchange rate from its USD price, we divide USD/BTC by EUR/BTC to arrive at the implied Bitcoin exchange rate. A graphical distinction between Bitcoin price (BTC) and the implied Bitcoin exchange rate is illustrated in Figure 2.

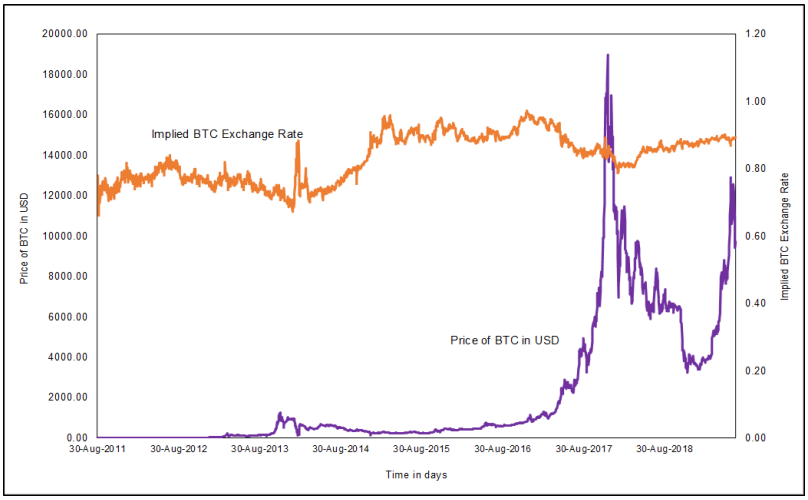

Figure 2. Time Plot BTC Price in USD and Implied BTC exchange rate (Source: Own graphics)

It transpires that, unlike the Bitcoin's USD price, the implied Bitcoin exchange rate trends well with other financial time series for JSE All Share Index (in Panel A of Figure 3), and USD/ZAR exchange rate (in Panel B of Figure 3).

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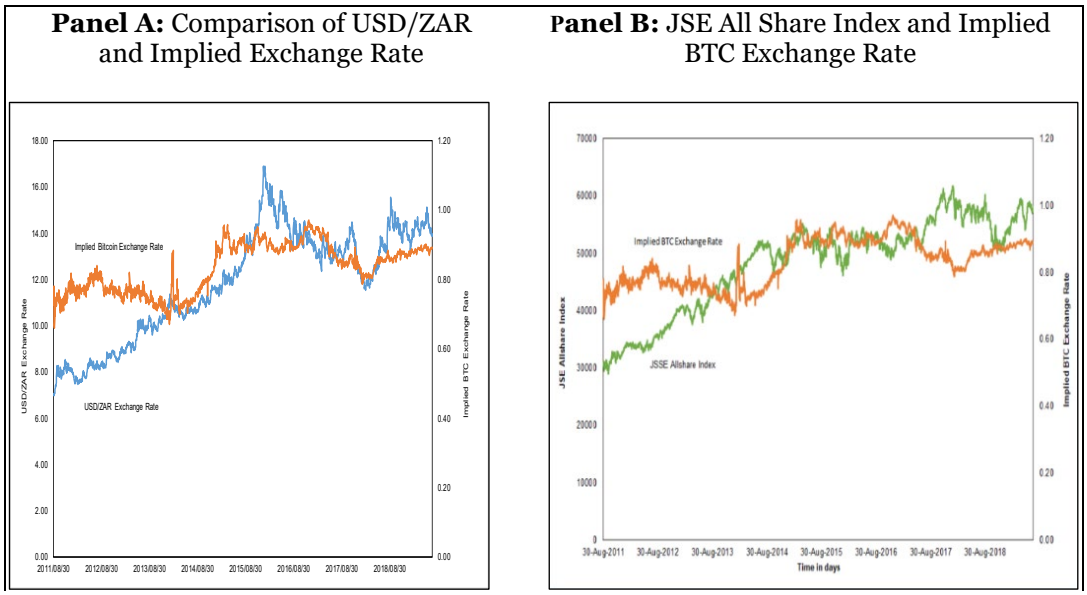

Figure 3. Time Plot of JSE All Share Index, Implied BTC, and USD/ZAR Exchange Rates (Source: Author's own graphics)

The data sets for daily prices were sourced for the period 30 August 2011 to 17 July 2019. The starting date was limited by data availability, while the end of the sample range was purposefully chosen to avoid data contamination risk from the COVID-19 pandemic. The time series data for USD/EUR, BTC/USD and JSE All Share Index were sourced from the online databases of Yahoo Finance and Iress database, respectively. Table 1 presents the descriptive summary statistics of the variables. A sample size of 1,969 for each time series was used. All three variables show a comparable average of approximately 0.03% and consistent standard deviation of around 1%. The evidence of kurtosis and skewness are consistent with the familiar stylized facts of financial return (Enders, 2003).

Table 1. Summary of Descriptive Statistics

Statistics	***JSE All Share Index***	***USD/ZAR Exchange Rate***	***Implied BTC Exchange Rate***
Mean	0.0003	0.0003	0.0002
Standard Deviation	0.0093	0.0101	0.0131
Kurtosis	1.3618	1.8760	9.3486
Skewness	-0.1583	0.4381	-0.3286
Minimum	-0.0362	-0.0338	-0.1055
Maximum	0.0416	0.0625	0.0945
Observations	1969	1969	1969
Source: Own computations			

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Empirical Results

EGARCH Model

This section presents the empirical results (in Table 2) regarding Bitcoin's volatility dynamics against the South African stock, and USD/ZAR foreign exchange markets. The empirical model was validated through the standard statistical procedures, including stationarity test using the augmented Dickey–Fuller (ADF) method by Dickey & Fuller (1979). The ADF test was confirmed with the regular alternative test proposed by Phillips & Perron (1988). The post-modelling validation of no-arch effects was tested and yielded satisfactory results displayed in Table 4 (in appendix).

The results in Table 2 were generated from the EGARCH (1, 1) model presented in Equations (1) and (2). Panel A in Table 2 shows results for the mean equation. The results indicate that all three variables (stocks, USD/ZAR, and Bitcoin) respond to each other's shock in the mean equation (that is, $\delta_1 > 0$ and $\delta_2 > 0$). Panel B shows the regression coefficients of the variance equation, and all parameters are strongly statistically significant, except the asymmetry coefficient for Bitcoin. This insignificant coefficient ($\gamma = 0$) means that own Bitcoin shocks are symmetric. Disturbances of equal magnitude have a similar effect, irrespective of their direction (negative or positive).

The shocks for JSE stocks are asymmetric ($\gamma < 0$), meaning that negative shocks have a higher impact than their equivalent positive disturbances, while USD/ZAR has opposite results in that positive shocks have a higher impact ($\gamma > 0$). The parameter β captures persistence in variance innovations. If β approaches 1, then the system is persistent. This means that a disturbance or shock may prolong its effect before it diminishes. All the three series have persistent shocks.

At this point it is important to reiterate that the objective of this empirical evaluation is to examine the relatedness of Bitcoin's volatility spillover dynamics to JSE stocks and USD/ZAR markets. In this context, volatility is deemed to spill over between markets if either or both λ_1 and λ_2 are statistically significant. In this regard, Panel B (x_i shocks) shows that both JSE stocks and USD/ZAR have bidirectional volatility spillover, while Bitcoin neither gives nor receives volatility shocks to/from the South African financial markets under examination. This is an interesting revelation, since Bitcoin is known to be highly volatile, yet the variances for both stock market and foreign exchange are unaffected by the observed Bitcoin volatility, other things being equal. Panel C displays the rest of the model properties. First, the stability condition of EGARCH model is satisfied for all variables, as evidenced by $|\beta| < 1$. Second, both

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stock and USD/ZAR markets have asymmetric shocks, but not Bitcoin. Lastly, leverage exists only in stock market but none in the exchange markets under consideration.

Table 2. Empirical Results

Details			**Output for EGARCH (1, 1) – (*p*-values in brackets)**		
Panel	**Variables**		**JSE All Share Index**	**USD–ZAR Exchange Rate**	**Implied BTC Exchange Rate**
A	Mean equation	Series' own lag (ϕ)	0.0109 (0.6352)	-0.0193 (0.3945)	-0.2548 (0.0009***)
		JSE All Share Index (x_i)		-0.0017 (0.0009***)	-0.0001 0.3943
		USD/ZAR Exchange Rate (x_i)	-0.0014 (0.0000***)		0.0008 (0.0009***)
		Implied BTC Exchange Rate (x_i)	0.0001 (0.8870)	0.0007 (0.0009***)	
B	Variance equation	ω	-0.2728 (0.0000***)	-0.2831 (0.0000***)	-0.3558 (0.0009***)
		α	0.0497 (0.0005***)	0.1128 (0.0000***)	0.2577 (0.0009***)
		γ	-0.1260 (0.0000***)	0.0379 (0.0000***)	0.0084 (0.5209)
		β	0.9756 (0.0000***)	0.9791 (0.0000***)	0.9830 (0.0009***)
		JSE All Share Index (x_i)		-0.0213 (0.0420**)	0.0040 (0.6981)
		USD–ZAR Exchange Rate (x_i)	0.0637 (0.0000***)		0.0120 (0.3956)
		Implied BTC Exchange Rate (x_i)	-0.0077 (0.5723)	0.0194 (0.1077)	
C	Stability condition	$\lvert\beta\rvert < 1$	Yes	Yes	Yes
	Asymmetry exists	$\gamma \neq 0$	Yes	Yes	No
	Leverage exists	$\gamma < 0,\ and\ \ \gamma < \alpha < -\gamma$	Yes	No	No

Notes: Statistical significance at * 1% ** %5**
Source: Own computations

The table provides results for the empirical model, EGARCH (1, 1), as outlined in equations 1 and 2. Overall the model is well validated in row C. Generally, the results indicate that there is some connectivity of Bitcoin with the South African exchange rate but none with the stock market.

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VCC-MGARCH Model: Robustness check

For robustness check, the results of EGARCH are extended with VCC-MGARCH where the model mathematics are presented in Equation Box 2 (in appendix), and the results are reported in Table 5 (in appendix). The model is appropriately validated with Wald test being statistically significant; and the parameters governing the correlation process (λ_1, and λ_2) are also significant and satisfy the relevant econometric condition, $0 \leq \lambda_1 - \lambda_2 < 1$. Further, the stability condition of the model is validated through the sum of Arch and Garch coefficients. The VCC-MGARCH is a parsimonious model that is suited to study the volatility spillover on a tri-variate system of JSE stock market, Bitcoin, and USD/ZAR exchange rates. Overall, the results of the two sets of models (EGARCH and VCC-MGARCH) are consistent and the original results are confirmed in the main. The results in Table 5 (in appendix) reveal several observations, including that, similar to the univariate models, the mean equations show that the variables are influenced by their own lags but less by the others. Further, the model captures the short- and long-term volatility spillovers well across the three variables. Most importantly, the results show that the correlations for Corr(JSE, USD/ZAR), and Corr(USD/ZAR, BTC) are statistically significant, confirming the bidirectional shock transmission observed in the univariate models. Also, the correlation of Corr(JSE, BTC) is insignificant, which concurs with unrelatedness between the two variables seen in the first round of modelling.

Discussion of Results

The current study was conducted against the hypothesis that South African financial markets are integrated with global markets in view of published empirical evidence (Boshoff, 2006; Heymans & Da Camara, 2013; Boshoff & Fourie, 2017). Therefore, this created anticipation at the outset that a relatively new but very disruptive and volatile digital asset like Bitcoin is likely to be involved in volatility spillover with domestic financial markets. This is an empirical question that was answered in the current study. The study has used EGARCH (1, 1) to examine the spillover dynamics of Bitcoin in relation to the financial markets of South Africa (JSE stocks, and USD/ZAR), and confirmed the outcomes with VCC-MGARCH. Table 3 summarizes results intuitively. The findings highlight three key observations.

Table 3. Summary of mean and volatility spillover for Bitcoin, JSE stock, and USD/ZAR

No.	Details	Mean	Variance
1	Bitcoin vs JSE Stocks	None	None
2	Bitcoin vs USD/ZAR	Bidirectional	None
3	Stock vs USD/ZAR	Bidirectional	Bidirectional
This table provides a summary of results for Bitcoin's interaction relationship with the South African financial markets (stocks, and exchange rate).			

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First, Bitcoin is independent of the JSE stock market. This result is comparable with prior studies. Corbet et al. (2018) examined volatility spillover between Bitcoin and the S&P 500 stock market, *inter alia*, using the *frequency domain* analysis introduced by Baruník & Křehlík (2018), and found almost zero bidirectional shock transmission or volatility spillover.

Second, Bitcoin is a giver and recipient to/from USD/ZAR of shocks in the mean returns, and no volatility spillover in the variance. Corbet et al. (2018) studied the volatility spillover of Bitcoin in relation to six global financial markets, including foreign exchange. Consistent with the current study and employing the Total Spillover Index (TSI) proposed by Diebold & Yilmaz (2012), Corbet et al. (2018) found that Bitcoin gives (15.25%) and receives (4.18%) volatility measures to/from foreign exchange markets in the price level. The study also found that the two variables have an equal but very minimal (0.35%) bidirectional volatility spillover effect.

Lastly, the JSE stock market and the foreign exchange market (USD/ZAR) have bidirectional shock transmission, both in the mean and in the variance. Even though not conclusive, this is a very common finding in the literature, both in South Africa (Oberholzer & Von Boetticher, 2015) and in other countries. There is supportive evidence from emerging markets like India (Mishra, Swain & Malhotra, 2007), China (Jebran & Igbal, 2016), as well as from developed economies like the US, UK, Germany, Japan, and Canada (Francis, Hasan & Hunter, 2006; Aloui, 2007).

Even though the study was neither designed nor intended to answer this question, there is value in offering a perspective on why Bitcoin volatility spillover in the South African financial markets (stock and USD/ZAR) is non-existent. Since the South African financial markets are integrated with world markets (Samouilhan, 2006), it is possible that similar explanations given for other economies apply in the current study, as Bitcoin is still relatively small in relation to conventional markets (Gopane, 2019b). Another reason may be its speculative nature as a digital asset, coupled with its disconnectedness with financial market fundamentals.

Overall, our findings reinforce a trend of empirical results reaching a common conclusion that "cryptocurrencies are rather isolated from the other markets" (Corbet *et al.*, 2018, p. 30) and that Bitcoin offers investors potential opportunities for portfolio diversification (Carpenter, 2016) or risk hedging (Bouri *et al.*, 2017).

Conclusions

An empirical analysis of Bitcoin's volatility spillover in the South African financial markets (of JSE equity and USD/ZAR) revealed enlightening outcomes. The findings show that Bitcoin is independent of the JSE stock market but has bidirectional shock transmission with USD/ZAR

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in the mean return, but not variance. In line with expectations, the domestic financial markets (JSE equity and USD/ZAR) have bidirectional shock transmission in the mean and reciprocate volatility disturbances to each other. These results should be informative to JSE stock market investors who may want to explore Bitcoin as a portfolio diversifier. Monetary policy makers should find the results of volatility dynamics between Bitcoin and USD/ZAR beneficial.

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Appendix

Table 4. LM Test for Arch Effects

Variable	Statistic	Value	*P*-value
JSE Allshare Index	F(5,1957)	0.3372	0.8906
	Obs*R-squared, $\chi_{(5)}$	1.6899	0.8902
USD/ZAR Exchange Rate	F(5,1957)	1.0062	0.4124
	Obs*R-squared, $\chi_{(5)}$	5.0335	0.4118
Implied BTC Exchange Rate	F(10,1947)	1.5233	0.1248
	Obs*R-squared, $\chi_{(10)}$	15.2001	0.1249

Source: Own computations

This table provides post-modelling validation results LM Test for Arch Effects. The results are satisfactory.

Equation Box 2: Time-varying conditional correlation multivariate GARCH, (VCC-MGARCH)

$$h_{ij,t} = \rho_{ij,t}\sqrt{h_{ii,t}\, h_{jj,t}} \quad (2a)$$

$$q_t = \Pi z_t + \mu_t \quad (2b)$$

$$\mu_t = H_t^{(1/2)}\, e_t \quad (2c)$$

$$H_t = D_t^{(1/2)}\, R_t\, D_t^{(1/2)} \quad (2d)$$

$$R_t = (1 - \lambda_1 - \lambda_2)R + \lambda_1 \psi_{t-1} + \lambda_2 R_{t-1} \quad (2e)$$

where

$\rho_{ij,t}$ = correlations which vary with time

$h_{ii,t}, and\ \ h_{jj,t}$ = variances, and $h_{ij,t}$ are covariances.

q_t = *vector of response variables with dimension* $m \times 1$

Π = *coefficient matrix with dimension* $m \times k1$

z_t = *vector of covariates or lags of* q_t *with dimension* $k \times 1$

H_t = *dynamic conditional covariance matrix*

e_t = *identically distributed innovations with dimension* $m \times 1$

D_t = *diagonal matrix of conditional variances*

R_t = *matrix of conditional correlations*

R = *matrix of means responding to the dynamic process*

ψ = *rolling estimator of the correlation matrix*

λ_1, λ_2 = *constants that control the dynamic conditional correlation process,* $0 \leq \lambda_1 - \lambda_2 < 1$

Notes: In Equation 2a, the $h_{ii,t}\ and\ \ h_{jj,t}$ are derived from univariate GARCH systems, while $\rho_{ij,t}$ are computed from an elaborate dynamic process. Equation 2b is the mean equation.

Source: Adapted from Tse & Tsui (2002)

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Table 5. Results of Time-Varying Conditional Correlation MGARCH, VCC-MGARCH (2,1)

Equation	Variables	lag	Coeff.	Std. Err.	P-value	
JSE	JSE	L1	-0.0481	0.0258	0.0620	*
	USD/ZAR	L1	0.0000	0.0000	0.2990	
	BTC	L1	0.0121	0.0165	0.4640	
	ARCH	L1	0.0456	0.0327	0.1640	
		L2	0.2127	0.0525	0.0000	***
	GARCH	L1	0.5237	0.1883	0.0050	**
		Const	0.0000	0.0000	0.1740	
USD/ZAR	JSE	L1	0.0322	0.3278	0.9220	
	USD/ZAR	L1	1.0001	0.0003	0.0000	***
	BTC	L1	0.2430	0.2051	0.2360	
	ARCH	L1	0.1396	0.0389	0.0000	***
		L2	0.2109	0.0808	0.0090	***
	GARCH	L1	0.4757	0.2581	0.0650	*
		Const	0.0032	0.0031	0.3110	
BTC	JSE	L1	-0.0506	0.0228	0.0270	**
	USD/ZAR	L1	0.0000	0.0000	0.1760	
	BTC	L1	-0.3222	0.0245	0.0000	***
	ARCH	L1	0.5663	0.0661	0.0000	***
		L2	0.2723	0.0549	0.0000	***
	GARCH	L1	0.0194	0.0760	0.7980	
		Const	0.0000	0.0000	0.0000	***
Corr (JSE, USD/ZAR)			-0.2056	0.0286	0.0000	***
Corr (JSE, BTC)			-0.0220	0.0321	0.4930	
Corr (USD/ZAR, BTC)			0.0619	0.0303	0.0410	**
/Adjustment, Lambda1	λ_1		0.0125	0.0124	0.0081	***
Lambda2	λ_2		0.9021	0.1449	0.0000	***
Wald Test, $\chi^2_{(9)}$				1.65e07	0.0000	***
Number of observations				1524		
Notes: Statistical significance at		***** 1%**	**** %5**			
Source: Own computations						

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Fallen into the Chasm: Exploring Mobile Payment Failed Initiative in Lebanon

Loubna Alsaghir
CEDREC, Faculty of Economics, Saint-Joseph University of Beirut

Abstract: Several years after introducing the mobile payment service to the Lebanese market, it is clear that the new payment method has failed to take off, which brings up questions about the reasons behind these unmet expectations. The current paper uses the Technology-Organization-Environment framework to explore the factors with respect to its three pillars that could have prevented the diffusion of mobile payment into the market. Using a qualitative approach of multiple case studies, the findings suggest that the reasons for the low diffusion of mobile banking lies as much in the incompatible nor open technology as in the highly competitive organizational structure of the banking industry and, finally, the merchants' and consumers' unwillingness to adopt it.

Keywords: Mobile payment, Technology-Organization-Environment framework, network externalities, critical mass.

Introduction

Between 2014 and 2016, the Lebanese payment market has experienced a new wave of innovation with the introduction of new mobile payment initiatives launched to compete with the already existing payment methods, such as credit cards or cash payment. The key drivers behind this initiative were not only the relatively young population, who are educated and open to innovation, but as well the fairly high penetration rate of smartphones, either in terms of users' percentage or in terms of connectivity. At the time of the introduction of the innovative payment service, and according to the Pew Research Center survey (Poushter, 2016), 52% of the Lebanese population owned a smartphone. And Internet penetration was estimated at 76% in 2016, according to the Digital 2020[i] report.

Several years later, there is no doubt that the new payment method has failed to take off, which brings up questions about the reasons behind these unmet expectations. The first question one could ask is related to the Lebanese payment market characteristics and readiness for such

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innovative service, which could be far from being adequate to stimulate large diffusion. Another argument could be examined on the service supplier's side by assessing the effectiveness of the adopted strategy to introduce the new service to the market. These two sets of arguments are supported by two theoretically well-grounded facts. Firstly, and unlike any traditional market for goods and services, the payment market is a multi-sided market, as defined by Rochet & Tirole (2003, 2006), as it involves, at least, three stakeholders, namely, the financial institution providing the payment service on one side, and the merchants and customers on the other sides who should accept it. Therefore, for any innovation in payment systems to succeed, it has to "get everybody on board", which was obviously not the case in the Lebanese payment market. Furthermore, the highly competitive financial sector, in addition to the relatively burgeoning number of mobile payment technologies, resulted, within the sector, in a "standards war", in the sense of Shapiro & Varian (1999), as each bank offered to the market a different and yet not compatible technology. Nevertheless, at the end of the battle, neither consumers nor merchants did show any enthusiasm for the innovation, regardless of the technology used.

As a consequence, it could be inferred that the failed mobile payment adoption in Lebanon lies as much in the technological immaturity as in the inter-enterprise organizational issues and, finally, the merchant-consumer lack of responsiveness. Viewed from this perspective, it is possible to group these hurdles into the three contextual categories of the Technology-Organization-Environment (TOE) framework as initially described by Tornatzky & Fleischer (1990), i.e., the technological, the organizational and the environmental contexts. However, although the original framework and its subsequent extensions were exclusively used as an organization micro-level theory that explains the elements of a single firm's context that influence adoption decisions, this analysis aims at extending it to a meso-level scope in order to explore the factors that are at stake when multiple companies – in our case banks – launch an innovative service – in this case the mobile payment service – that is supposed to be adopted by two different sides of the market, namely merchants and consumers.

Therefore, the main purpose of this paper is to look at the causes of the failed mobile payment initiative in Lebanon from a service provider's perspective. Despite the growing interest in studying mobile payment adoption from the end-users' perspective ("the demand-side"), little attention has been given to the contextual factors which may affect innovative service providers ("the supply-side") and could either enable or impede innovation diffusion. These factors challenge the global strategy deployed by the service provider in its attempt to launch a new mobile payment service and could very likely prevent the service from reaching a critical mass of consumers. Thus, the research question could be formulated as follows: *What factors make the bank's deployed strategy for mobile payment introduction effective for innovation*

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diffusion? If we assume that an innovation introduction strategy is "effective" when a "critical mass of users" is reached, then what are the factors that help cross the "chasm" – a concept borrowed from Moore (1999) – and reach large-scale diffusion? To be more specific, to what extent could the type of used technology be a critical factor for innovation diffusion? Has the competitive environment a role to play in that regard? What kind of strategy towards both merchants and consumers should be deployed in order to get "everybody on board" in a multi-sided market?

The originality of this study lies mainly in the methodology, i.e., the model used to analyse the case. In fact, as far as we know, the TOE framework has never been used to examine the interactions that exist between companies that decide collectively to adopt a new innovation (Baker, 2012). Besides, the type of technology described, i.e., payment technology, has its own dynamics, as it involves interactions between two different kinds of end adopters, merchants and consumers, where each category's adoption decision depends upon the number of the other's category who have adopted that innovation. Such technologies, which are known to generate "network effects" of "positive network externalities" in the sense of Katz & Shapiro (1985), have never been placed in the mould of the TOE framework. Therefore, integrating all the dynamics that come into play between multiple companies and multiple end adopters of an innovation would highly contribute to enriching the explanatory power and the external validity of the said TOE framework.

The rest of the paper is structured as follows. After reviewing the literature on the various models used to explain the reasons for mobile payment (un)successful adoption, a TOE-extended model will be drafted and tested in the context of mobile payment adoption in the Lebanese market. To this end, data was collected and interviews were conducted with key individuals in four large Lebanese banks, three of them being commercial banks and one specialized bank. Discussion of results and conclusions will end the paper.

Mobile Payment Adoption across Competing Models and Perspectives in the Literature

The mobile payment literature is largely dominated by models analysing the factors or variables that affect consumers' attitudes towards mobile payment. Listing the most used models chronologically, as done by Liu, Ben & Zhang (2019), shows that to analyse consumers' behaviour in terms of mobile payment adoption researchers used either the Theory of Reasoned Action (TRA) of Fishbein & Ajzen (1975), or Roger's (1983) theory of "diffusion of innovation" (DOI). Later, Davis, Bagozzi & Warshaw (1989) suggested the first version of the Technology Acceptance Model (TAM), followed by two other extensions, namely TAM2 and TAM3, adding for each version new determinants and variables reflecting a more in-depth

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analysis of the personal characteristics and perception of individuals towards innovation (Venkatesh & Davis, 2000; Venkatesh & Bala, 2008). The most recent models show a more unified and synthetic view of all variables and are known as "Unified Theory of Acceptance and Use of Technology", UTAUT and UTAUT2 models (Venkatesh *et al.*, 2003; Venkatesh, Thong & Xu, 2012). Researchers also borrowed from other fields of study theories that explain the factors that lead consumers to "migrate" or "switch" from one technology to a new one, namely the Push-Pull-Mooring framework, initially elaborated by Lee (1966) to explain geographic migrations (Liu, Ben & Zhang, 2019; Loh *et al.*, 2021; Wirth & Maier, 2017). Also, the *Status quo bias* theory of Samuelson & Zeckhauser (1988) has been used to explain the reasons why consumers decide to resist change and prefer sticking to their old and well established habits (Gong *et al.*, 2020; Loh *et al.*, 2021; Zhang *et al.*, 2016).

The major limitation of these models relies in their exclusive focus on the consumers' perceptions and characteristics that could affect, either positively or negatively, their attitude towards mobile payment and therefore their intention to adopt or continue using it. In fact, it should be taken into consideration that, sometimes, positive attitude does not necessarily translate into adoption; the attitude-behaviour relationship, as initially suggested by Fishbein & Ajzen (1975), shows the complexity of factors that are at play, either socially or psychologically, in the decision-making process. Besides, the mobile payment technology involves several stakeholders interacting in a "multi-sided platform", as defined by Rochet & Tirole (2003). One important feature of such platforms is the presence of "cross-side network effects" along with the same-side network effects (Hagiu & Wright, 2015). In other words, for the consumers (one side of the platform) to be attracted by mobile payment, not only should there be a significant number of consumers who have "joined" the platform (same-side network externalities) but, as well, and not less importantly, there should be enough merchants (the other side) that have accepted the said payment technology (cross-side network effect). This would help reaching a "critical mass" of users and result in a successful innovation diffusion (Evans & Schmalensee, 2010).

Inferring that the "blockage" could come from the merchants' side has also been documented in the literature, even though to a lesser degree (Boateng, Yeboah-Afeti & Afful-Dadzie, 2019; Moghavvemi *et al.*, 2021; Khan & Ali, 2018; Liébana-Cabanillas & Lara-Rubio, 2017; Mallat & Tuunainen, 2008). However, here as well, analysing the merchants' perspective in isolation from the consumers' would give again scant knowledge of the interactions existing between both sides of the market.

In an earlier study, Mallat & Dahlberg (2005) analysed the adoption of mobile payment solutions by consumers and merchants and suggested drivers and barriers that could help or, on the contrary, prevent both sides' adoption. Similarly, work was also carried out on how to

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attract users on both sides in order to "get everybody on board", resulting in the commonly called "chicken and egg" dilemma (Caillaud & Julien, 2003) or the "which one to attract first" question. That is to say that, in order to attract consumers to the new payment method, there should be enough merchants who accept it, and vice versa.

All these elements of thought suggest that, when looking at factors of innovation adoption, not only adopter-side variables significantly influence innovation, but also supply-side variables (Frambach *et al.*, 1998), i.e., the strategy deployed by the technology provider to reach the market. And this strategy should be implemented upon a close and intense scrutiny of the context in which the innovation is about to be deployed. That is to say that our approach is a rather integrative one, as it analyses the mobile payment ecosystem as a combination of forces and powers between technology producers, consumers, merchants and regulators that interact simultaneously in a dynamic model (Au & Kauffman, 2008; Dahlberg, Guo & Ondrus, 2015).

Analysing mobile payment adoption from the suppliers' perspective leads to considering the Technology-Organization-Environment (TOE) framework as a potentially powerful analytical tool. In fact, it helps companies assess their readiness toward an innovation target market by exploring all the contextual elements in terms of technology, organization and environment that could impact the implementation of the technology. Nevertheless, this framework will be challenged in a different analytical perspective

In fact, the original TOE framework by Tornatzky & Fleischer (1990) has been used, in the literature, mainly to explain the factors that lead SMEs to adopt the mobile payment technology (Kwabena *et al.*, 2021; Khan & Ali, 2018; Uwamariya & Loebbecke, 2020), as it was used, as well, to predict the performance of companies that have adopted it (Mahakittikun, Suntrayuth & Bhatiasevi, 2021). Some attempts have also been made by researchers to extend the original TOE framework by integrating elements related to the theories of technology adoption by consumers, resulting in a TOE-DOI framework (Khan *et al.*, 2021).

However, all these works were conducted from the perspective of a single company, i.e., the merchant who decided to choose the technology to adopt according to some specific criteria, like compatibility or relative advantage. There is no study done, so far, that focuses upstream in the process on the supply of the mobile payment service by financial institutions and its delivery to both merchants and consumers. Moreover, most studies were done on mobile payment third-party platforms (like Apple Pay or Google Pay) while overlooking the case of a bank-centred model, although banks could show a significant competitive advantage in the mobile payment ecosystem (Gaur & Ondrus, 2012).

The main contribution of this paper is to fill this gap by highlighting the contextual factors that are at stake when several banks decide to launch a new payment service intended for two

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different categories of customers. The TOE framework will be used as a road map to structure our reasoning in analysing the determinants of mobile payment adoption when multiple firms, i.e., banks, offer a technology to multiple kinds of customers, i.e., merchants and consumers. In doing so, the TOE framework is extended to a meso-level analysis as a tool aimed at predicting the readiness of not only a single company like all previous studies, but rather that of the whole payment multi-sided market in its three components: banks, merchants and consumers, all interacting together.

A TOE Extended Model

For each one of the three poles of the TOE framework, namely the technology, the organization and the environment, there will be a listing of the main factors that were used by researchers in defining each pole, complemented with an in-depth reflection into how to transpose it to a market, multiple-firm, meso-level analysis.

The Technological Context

From the companies' perspective, the technological context refers to all the technologies that are at their disposal, whether they are already in use inside the company or available in the marketplace (Baker, 2012). The decision of choosing a specific technology relies on the type of innovation the company is considering in terms of the pursued scope of change, be it a radical or an incremental change. Most of the literature that used the TOE framework to analyse mobile payment adoption agreed, to different extents, to the technological criteria defined by Orr (2003), namely the comparative advantage, compatibility, complexity, testability and observability.

However, from the perspective of the entire mobile payment market, when several companies decide to venture out and offer a radically new technology, the necessary condition of reaching a "critical mass" of users (Evans & Schmalensee, 2010) for a successful adoption brings into play new considerations. Firstly, as several and yet incompatible mobile payment technologies exist, banks are expected to engage in a battle for market dominance *à la* Shapiro & Varian (1999) with the aim of imposing their own technology as a standard. And, as in any battle, collateral damage could occur, especially when no standard dominant model emerges, preventing the technology from taking off. Specifically, the technological, service design and business model competition could blur the market and consequently lead to a lack of stakeholders' support, which ultimately would prevent the emergence of a dominant design in the payment market (Dahlberg *et al.*, 2008; Ozcan & Santos, 2015).

Another consideration to be thought of as regarding the different competing technologies is in terms of their "openness" at both the "technology level" and the "user level", as suggested by

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Ondrus, Gannamaneni & Lyytinen (2015) in their study on multi-sided platforms. The first dimension, i.e., openness at the technology level, is related to the compatibility and interoperability of a technology with related technologies; while the second one, the openness at a user's level, is its aptitude to be accessible in indiscriminate ways to users. The same concept could be transposed here to assess the extent to which the chosen mobile payment technology is compatible with, interoperable between, or discriminates between different segments of the customer base, affecting through this the potential of any market to reach a critical mass.

From this perspective, and with respect to the technological context, the following proposition could be formulated:

Proposition 1 – For the mobile payment market to reach a critical mass, a standard open technology should be deployed across the market

The Organizational Context

From a company's perspective, the organizational context refers to its characteristics in terms of organizational structure (organic and decentralized or mechanistic and centralized), as well as in terms of intra-firm communication processes and resources (financial and human) that influence its receptiveness to the adoption of innovation (Baker, 2012). Most studies that used the TOE framework adopted proxies like top management support, technological competency and employees' readiness to assess the organizational context (Khan *et al.*, 2021; Kwabena *et al.*, 2021). These factors relate to a firm's internal processes that should be linked together in a "coherent whole" and consistent with the adopted innovation strategy to guarantee success.

At a broader market level, one could extrapolate the reasoning by looking at inter-firm relationships, i.e., the type of competitive patterns that rule the market, specifically when an innovation is deployed. In that regard, three different kinds of inter-firm organizational models were identified in the literature, namely the competition, the collaboration and the co-opetition models (Hedman & Henningsson, 2015; Ondrus, Gannamaneni & Lyytinen, 2015). The competition model is when one firm provides a technology and competes against the others in the ecosystem. On the other side of the spectrum, the collaboration model is when multiple firms from different industries collaborate to provide an inter-industry model. Between these two patterns, the co-opetition model is when competing firms within the same industry decide to collaborate and provide a single intra-industry model within the ecosystem.

The last model seems to draw more of our attention. In fact, for a competition model to succeed, go-it-alone firms have the tough challenge not only to show technological superiority but also to deploy an aggressive strategy towards stakeholders to build trust and dependencies

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(Reuver & Ondrus, 2017); whereas the co-opetition model has the merit of reducing the clash between competitors and, in accordance with what has been said earlier, would increase the potential of the market (Hedman & Henningsson, 2015; Ondrus, Gannamaneni & Lyytinen, 2015). In a similar way, the co-opetition model has proven to be efficient in terms of innovation performance in markets characterized by high positive network externalities and low competition intensity (Ritala, 2012). Although the mobile payment market in Lebanon is a rather highly competitive one, it would be of interest to challenge this assumption by formulating the following proposition:

Proposition 2 – For the mobile payment market to reach a critical mass, the co-opetition model between banks is superior to the competition model.

The Environmental Context

The environmental context of a firm refers to all factors that fall outside its borders and could affect the adoption of innovation. These factors include the competition intensity, the size and age of the industry, the pressure from suppliers and consumers and, finally, government regulation.[ii]

Given that our aim is to explore the mobile payment market from an integrative perspective, the environmental context will comprise all factors that fall outside the banking sector and could affect the successful adoption of innovation. Hence, the focus will be on the critical role of both merchants and suppliers in their acceptance of the new payment service and the multiple dynamics resulting from the network externalities that come into play in a multi-sided market, as suggested by Rochet & Tirole (2003), both in terms of same-side effects and cross-side effects (Hagiu & Wright, 2015). Several researchers highlighted the fact that these externalities could be the most influential driver of mobile payment acceptance (Qasim & Abu Shanab, 2016; Wang, Lo & Fang, 2008; Mallat, 2006). Besides, Pantano & Viassone (2014) pointed to the fact that, when retailers are neither prepared for — nor supportive of — a technology-based innovation that could improve their business, the diffusion process is hindered and expectations of both retailers and customers fail to be met. Therefore, for a successful adoption of innovation, firms have to implement a strategy aimed at "getting everybody on board" and, in doing so, they would be "internalizing" the externalities and reaching more rapidly and easily the critical mass.

The following proposition could be formulated as a result:

Proposition 3 – For the mobile payment market to reach a critical mass, a merchant-consumer joint incentive strategy should be deployed by the banks.

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Research Methodology

The research methodology used to answer the question of assessing the readiness of the Lebanese payment market to mobile payments is a qualitative case-study-based methodology. According to Robert Yin (2009), this strategy "contributes to our knowledge of individual, group, organizational, social, political, and related phenomena", as it also allows one to get in-depth and holistic insights of "real-life events such as individual life cycles, small group behaviour, organizational and managerial processes, neighbourhood change, school performance, international relations and the maturation of industries" (Yin, 2009). In that respect, this study seeks an in-depth understanding of the strategies deployed by mobile payment service providers in order to identify the factors that were at stake when the service was launched and that could have caused its failure. Therefore, focusing on the "why" adoption failed and on the specific "organizational behaviours" perspective gives credit to the chosen qualitative research approach.

Our case study covers the four large Lebanese banks that implemented a mobile payment initiative during the period from 2014 to 2016,[iii] three of them being commercial banks and one a specialized bank. The originality of this sample of banks relies on the fact that each bank implemented, at that time, a different mobile payment technology, which has the great potential of enriching our study by helping cover and compare the four different scenarios implemented. The four deployed technologies[iv] could be grouped into two main categories, namely the NFC-enabled technologies and the mobile payment applications. Hence, two banks implemented two variations of the NFC-enabled technologies, namely the "SIM Based Secure Element" and the Host Card Emulation technology. The two other banks deployed mobile payment applications in the form of QR code technology and a "white-label mobile payment solution".

Another originality of the sample stems from the strategy adopted by each bank to reach the market. The three commercial banks fit into the "competition model", as described earlier, as they decided to compete against each other by providing different technologies, strategies and approaches to the market. Conversely, the fourth bank, which is specialized in offering innovative payment solutions to the banks that are members of its network, adopted a horizontally-integrated solution by providing a single intra-bank technology within its network. Fourteen banks in this network were invited to collaborate and adopt the suggested mobile payment "white-label" application and provide the service to their respective customers. Therefore, the resulting organizational scheme fits into the "co-opetition framework" of competing banks within the same industry offering a single intra-industry technology.

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The data collected was twofold. First, secondary data was collected from the websites of the four banks in relation to their mobile payment initiatives, as well as from the press releases and other media supports in which they announce and advertise their technology. The messages these banks want to convey through the media usually provide meaningful insights into their implementation strategy. Secondly, primary information was collected through interviews conducted with representatives of the four banks, who were directly involved in the mobile payment initiative since its inception until the end of its implementation. The main points discussed during these interviews aimed at gaining more insights into the technology deployed and the strategy implemented by the bank towards the merchants on one side and towards customers on another. The aim was also to highlight the major obstacles encountered by the banks during implementation and the strategy adopted to overcome them.

The interviews lasted for an average of one-and-a-half hours and the "conversation" was led on the basis of a semi-structured interview guide. The rationale for using semi-structured interviews for data collection stems both from its flexible and versatile nature, as it allows space for participants' expression, especially on issues that are meaningful for them, and where they have to discuss their own perceptions (Cridland *et al.*, 2015) specifically on sensitive subjects like success or failure. The interview guide was elaborated following the five-step process as presented by Kallio *et al.* (2016). The main discussed themes were a reflection of the formulated propositions and cover mainly four topics: a thorough description of the used technology; the strategy adopted towards both customers and merchants; the obstacles that were encountered and how they were dealt with; and, finally, an overall assessment of the success of the mobile payment initiative as compared to other innovative services offered by the bank. In order to gain accurate, in-depth and optimal information, follow-up questions were pre-designed with the aim of guiding the discussion. These follow-up questions were then refined and enriched after the first interview, which served as a pilot field-test. In doing so, not only has the coverage of the interview guide been improved, but, as well, the complete guide gained in terms of reliability as it allowed for identical data collection across cases and consequently enabled optimal comparability.

The main case study findings are presented within a cross-case display, as suggested by Miles & Huberman (1994), more specifically in a *case-ordered predictor-outcome matrix*, where the main outcome (or *criterion variable*) is "reaching a critical mass for mobile payment" in the Lebanese market, what we considered as being a successful adoption; whereas the predictors (or *antecedent* variables) are related to the specific technology deployed (its characteristics and the technical constraints imposed on adopters) and to the strategy adopted by the bank during the implementation process; and finally the hurdles it had to face. Such cross-case display allows for making contrasts and comparisons between cases in order to see whether

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the antecedents account for the criterion variable. Table 1 shows the main findings within the said cross-case display.

Table 1. Cross-case main findings matrix

	NFC Technology		**Mobile payment application**	
	Competition models			**Co-opetition model**
	SIM-Based Secure Element	**Host Card Emulation**	**QR Code Technology**	**White-label mobile payment solution**
Initiative launch date (press release)	April 2014	November 2016	February 2016	February 2016
Technological characteristics	Secure element tied to the SIM card.	Cloud-based secure element	Mobile app. Authentication system. Card-not-present method.	Mobile app. Authentication system. Technology supplied by **a specialized bank** to 14 member-banks technically integrated to their system/network. "white-label" app.
Technical needs of customers	NFC enabled smart-phone or contactless watch, bracelet or sticker.	Any Android 4.4 device that supports the HCE technology	Any device equipped with a camera – QR code scanner.	Application available both on the Google and Apple Stores – Should have an account in any of the 14 member banks who should in turn offer the service.
Technical needs of merchants	Contactless NFC terminal at the POS	Contactless NFC terminal at the POS	QR code reader tablet.	Tablets with the App on it.
Strategy towards customers	**Advertising awareness campaigns** targeting young consumers/activities with long payment lines – **Monetary incentives** cash back	**Awareness of young population on social media** to a "trendy" way of payment No monetary incentive.	Targeted consumers: university students – "On-campus" demos and trials. Monetary incentives.	**The primary customers are the affiliated banks to the network.** ***Strategy towards banks:*** **turnkey technology,** no investment expenses – no upgrading fees – no membership fees – no administrative constraints **Banks have to promote the MP app to their own customers.** Targeted niche: the delivery market.
Strategy towards merchants	**Monetary incentive:** initial set-up and NFC enabled terminal	No specific action towards merchants. They are "supposed" to be equipped with	Tablets offered to merchants – Training of cashiers, employees –	Tablets that accept the App offered to merchants – plus

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	NFC Technology		Mobile payment application	
	Competition models			Co-opetition model
	SIM-Based Secure Element	**Host Card Emulation**	**QR Code Technology**	**White-label mobile payment solution**
	rented to merchants at reduced fare – **Training** of merchants **Awareness raised** as to its benefits: shorter queues – more benefits – competition	the necessary upgraded terminal.	Reduced commissions – Earliest value redemption date	Internet and maintenance. Training of cashiers Monetary incentives: zero commission – Cash-back (compensated by the specialized bank/service provider) - Immediate cash receipt
Adoption hurdles	From customers' perspective: need to change the SIM card – Young customers not enthusiastic for "plastic" bracelets nor watches and even for sticker on the I-phone. From merchants' perspective: need to invest in the new NFC enabled terminal – Did not find the worth of using it – customers are not asking to pay through it. Existence of widely admitted payment substitutes	From customers' perspective: Not all customers / not all payment cards: Android devices only and "credit" cards only. Visa cards. Security concerns – Resistance to change.	From customers' perspective: limited market niche. From merchants' perspective: cumbersome "another terminal to put on the counter" – tablet not charged – the trained cashier is not on duty.	From the affiliated banks' perspective: did not take ownership of the solution – did not see relative advantages compared to payment substitutes. Did not promote it. Asked for exclusivity. From the merchants' perspective: Excessive turnover of cashiers: training lost. Too many payment terminals: confusion.
Overall banks' assessment of its MP initiative	Not a success – Better results not expected – Market exploration – Technical constraints admitted – Improved solutions to come ("e-wallet")	The bank is rather satisfied, although adoption rate is low. Same importance given to all payment methods delivered by the bank. No strategy of cannibalization between products.	The P2M (pay to merchant) success is limited due to lack of interest/education/ awareness. P2P option more successful.	MP was not largely adopted by both banks and merchants. Banks did not collaborate: no effort (advertising) for a solution that could benefit competitors as well. Merchants confused: too many payment alternatives and limited volume of transactions.

Results and Discussion

The main finding according to all respondents is that the diffusion of mobile payments to the Lebanese market was rather limited in terms of the percentage of customers who adopted this

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innovative payment method. Despite this, the reduced outcome did not seem to disappoint the banks, as one respondent said that "*they did not expect any better results*", while others even expressed rather satisfaction with the outcome even though in its limited scope.

It seems obvious that the banks' objective was more focused on proactively exploring a new payment method rather than on improving market share or benefits. As one respondent said, "*it's just another payment option that is added to the already existing and various methods*". Similarly, another respondent added that "*it is just an exploration of the market to test its receptiveness to new ideas, and improved solutions are on their way in terms of e-wallet*".

This leads us naturally to question the "readiness" of the Lebanese mobile payment market in regard to the type of technology deployed and its diffusion, as well as to the competitive pressure that was prevailing in the market and the consequent behaviours of the technology's "adopters", i.e., merchants and customers. In other words, it is all about bringing together the pieces of the TOE framework puzzle, namely the technology, the organization and the environment, and challenge them at the market level, as specified in this research, rather than at a company's scope.

Concerning the first proposition related to the technological context, it was stipulated that, in order to reach a critical mass of adopters, the deployed technology should have reached a certain level of maturity and standardization; as it should, as well, be characterized by its openness, allowing the intended mass to adopt it. There is clear evidence that these two conditions were far from being met, especially given that the market is a rather small market in the volume of transactions being made. In fact, this small market has experienced within two years four different types of mobile payment technologies and no model could make it to the end and impose itself as a standard model. Moreover, and as stipulated by Dahlberg *et al.* (2008) and Ozcan & Santos (2015), it blurred the market, especially as concerning merchants who were cluttered with the myriad of technical supports associated with each technology, as well as the various technological drawbacks each one holds. This led them to naturally leave this payment method behind and rather opt for easier and well-established payment alternatives.

Furthermore, as concerning the openness of the deployed technologies, it is made clear that none of the four initiatives could be considered as "open", in the sense of Ondrus, Gannamaneni & Lyytinen (2015) of a technology that "is compatible and does not discriminate segments of the customer base". On one hand, the NFC-enabled technologies inevitably lead to exclude those customers with devices that do not support such technology. Although, an attempt has been made by the SIM-Based Secure Element technology provider to find solutions to get these customers back on track, through contactless watches, bracelets or

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stickers, the attempt was rather unsuccessful. On the other hand, the banks who provided the mobile payment application scheme, although offering a technically compatible solution, divided the market by segments of customers, addressing the service to young university students for one of the cases, and to the "delivery market" for the other. Obviously, these banks targeted a segment of the market that could be receptive to such a technology and value its comparative advantage. However, and although the strategy of "targeting a point of attack" was considered as key by Moore (1999) in order to cross the chasm, a no less critical issue is that the selected market niche should provide, by virtue of its connections, an entry point to a larger segment, which was obviously not the case given the limited diffusion of the payment service. Therefore, the many technological obstacles added to the rather low-scale and closed target niche market prevented the dynamics or process of reaching a critical mass of users.

As regarding the second proposition, which relates to the organizational context of the banking industry, the aim was to compare the effectiveness of the mobile payment implementation across two competing models, namely the competition and the co-opetition models; and, as stipulated earlier, the collaboration between competing banks through the deployment of a single intra-industry solution, the so-called co-opetition model, should theoretically result in better implementation results. The fourth case study describing the technology deployed by the specialized bank provides a perfect illustration of this model, since it was a "white-label" application intended to be adopted by fourteen of its member banks, who were, in turn, supposed to provide the mobile payment service to their respective customers.

Such a different scenario, compared to the three others, leads us to consider the member banks not only as intermediaries between the service provider bank and the potential customers, but also and more importantly as "facilitators". In fact, since they were asked to take ownership of the technology and put their own label on it, they were supposed to invest in the necessary resources and effort to support its diffusion to the market. Obviously, "*not enough coordination between member banks was witnessed*", as one respondent acknowledged, despite the many facilitating conditions that were provided to them. Moreover, by noting that "*banks asked for exclusivity*" and that they "*did not see the worth in advertising for a solution that could benefit competitors as well*", one could infer something about the intensity of the competitive pressure that prevails in the payment market, which compromised the diffusion of innovation. This allows for the conclusion that, in accordance with Ritala (2012), in a highly competitive industry, the co-opetition model did not prove to be efficient in terms of innovation performance as regards mobile payment adoption in Lebanon.

Finally, as concerning the third proposition related to the environmental context, it was suggested that the banks should deploy a strategy that aims at involving actively both merchants and customers in order to get them "on board". Indeed, the incentives provided to

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customers ranged from advertising awareness campaigns, to live demos and monetary incentives; whereas the strategy adopted towards merchants included monetary incentives, either in terms of offered equipment or reduced commissions or even reduced value dates, as well as training and awareness-raising campaigns. However, all these stimuli did not yield positive feedback in terms of large-scale adoption of mobile payments.

It could be inferred from the interviews that, as far as customers are concerned, two main factors could account for their low adoption rate. The first one is in relation to the *switching costs* associated with adopting the payment solution, either in terms of the incompatible device they possess or in terms of the learning costs related to changing a well-established habit. This assumption is in line with the major contribution of the *push-pull-mooring framework*. Moreover, the second adoption hurdle lies in the competition among the various payment alternatives and substitutes that exist in the Lebanese market, which leads us to reflect on the need for this additional alternative. It suggests that the success of the mobile payment initiative in sub-Saharan countries, like Kenya, Uganda, Tanzania, Zimbabwe and Somalia, stems from the important fact that, apart from creating an enabling regulatory environment, it was intended to meet the urgent needs of a poor population characterized by low financial inclusion and was therefore "led by the market" (Burns, 2018). The context of the Lebanese payment market is quite opposite since, even though the regulatory environment is favourable, the rate of the unbanked population is relatively low compared to the sub-Saharan countries[v] and the payment methods, ranging from cash payments to credit and debit cards or by cheque payments, are various and yet effective.

Therefore, this discussion raises again the old debate on whether innovation should be demand-pulled or technology-pushed. The mobile payment initiative in the Lebanese market is a typical case of a technology-push innovation that failed to pull the demand with it. The low adoption rate by customers is a clear illustration of their unwillingness to change payment habits that have proven satisfactory. The same goes for merchants who did not feel the "need" for this solution. Although banks tried to "create a need" by conveying the benefits of "*shorter checkout lines*" and "*faster money receipt*" or even "*increased number of transactions*", the message has obviously not got through. Here, as well, the wide range of existing payment alternatives led to increased confusion at the payment desks. These findings are in line with Pantano & Viassone (2014), who pinpointed the critical importance of both retailers' preparedness and support for technology-based innovations as well as consumers' positive attitude towards it. Added to this, the relatively small transactions volume, linked to the rather unfavourable economic climate that was prevailing at the time mobile payment was introduced, was also an important factor to account for the low adoption by merchants of this solution. As evidence of this, when asked about the position of merchants regarding this

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payment method, the answer was: "*what counts more for merchants is that the transaction be done regardless of how it is going to be settled*"; in other words, all payment methods are equal to merchants provided that the payment is done.

By way of synthesis, emphasis should be laid on the theoretical contribution of this paper. In fact, the originality of the study lies in its applied methodology, as it extended the scope of the TOE framework from a micro-company level to a wider meso-market level. The new upgraded theoretical framework provided a strong and reliable toolkit when put into practice, as it guided the analysis by shedding light on the critical factors that are at play when a technology-based innovation is introduced. Moreover, it helped uncover the complex dynamic that sets in between stakeholders, being banks, customers and retailers, especially for innovations that need an "adoption network" to enhance their diffusion.

Conclusions

In conclusion, the main objective of this paper was to explore the readiness of the Lebanese payment market for mobile payments through three main indicators, borrowed from the TOE framework, namely the technological context, the inter-firm organizational context, and the merchants-customers' environmental context. This model has the major advantage of allowing for an integrative approach, as it sheds light on all factors that are at stake when an innovation is introduced to a multi-sided market. As well, it shows the complex dynamics that are at play between all stakeholders, banks, merchants and customers.

Our four case-study findings suggest that the readiness of the Lebanese payment market to absorb the new payment method was not meeting expectations. The many factors accounting for this underperformance were equally linked to the multiple technologies deployed, to the inter-firm highly competitive pressure prevailing, and, finally, to the low responsiveness of both merchants and customers. The interesting fact is that these three factors were not acting in isolation, but were rather interrelated and mutually reinforcing each other.

In fact, from the deployed technology perspective, flooding the marketplace with multiple competing and incompatible technologies, together with their associated services, led to a battle of standards. Besides, this battle was all the more acute given the excessive competitive pressure in the banking industry, which prevented reaching a dominant standard model as each bank wanted to impose its own technology; all the more so, since merchants and customers did not adopt the deployed technologies, undervaluing its relative advantages compared to its costs, and significantly hindering the reach for a critical mass by any of the implemented technologies.

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However, and having said that, the difficulty lies in formulating proper recommendations for the practice. Indeed, it could be suggested that imposing a unique standard-open technology could help address both issues of a standards war and competitive pressure between incumbents. But, here again, what if the end adopters reject the technology for lack of interest, need or demand? Conversely, moving from downstream to upstream by exploring the market needs on the look-out for new ideas would more likely result in a rather incremental change, given the conservative nature of economic agents, especially in terms of payment methods.

In sum, this research has contributed to enrich not only the empirical literature on mobile payment, but also the theoretical corpus by extending the scope of the TOE framework, since it cuts across many conceptual frameworks of innovation economics (technology push-demand pull models), innovation management (Moore's chasm), network economics (multi-sided market models), organization and competition theories (competition versus co-opetition models) and technology acceptance and diffusion models. Although the main originality of the research lies in its focus on the upstream of the process, i.e., the banks that provided the service, some could see it as a limitation, since all results, inferences and conclusions came out of the "bankers' viewpoint". This is certainly to be acknowledged; however, it also leads to suggest further research on more in-depth micro-behavioural analysis at both customers' and merchants' ends in order to get more insights into their own adoption decision-making process, specifically when a new disruptive service technology is at play in a highly competitive and yet complex environment of multi-sided adopters. These research topics are all the more pertinent today in view of the changing behavioural patterns resulting from the COVID-19 pandemic and its corollaries, which largely challenges the pre-COVID-19 theoretical and empirical corpus and paves the way for new opportunities for research, science and technology.

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Endnotes

[i] https://datareportal.com/reports/digital-2020-lebanon

[ii] The role of both government and financial regulatory authorities is not addressed in this study, as these entities provided the necessary agreements in principle to the deployed mobile payment service.

[iii] This study is part of a larger research project conducted and financed by Saint-Joseph University and aimed at exploring the reasons of the failed mobile payment initiative in Lebanon. The project consists of two parts: a qualitative case study of the banking sectors and a quantitative survey of consumers. This paper reveals findings of the first qualitative part.

[iv] The name of the four Banks will not be disclosed, intentionally, and we will rather be referring to each one by the mobile payment technology it deployed.

[v] According to the World Bank Global Findex database for Lebanon in 2017, the rate of adults and companies who have bank accounts exceeds 45% and 92%, respectively (https://globalfindex.worldbank.org/). In comparison, the rate of inclusion in Kenya was around 26% for individuals before the introduction of M-Pesa (source: Kenya Economic Report, 2020 — https://kippra.or.ke/download/kenya-economic-report-2020-2/)

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University Students' Engagement with Devices and Technology

A Comparison of Pre- and Post-COVID-19 Student Use

Lucy Cradduck
QUT Law, Queensland University of Technology

Mark A. Gregory
Network Engineering Research Group, RMIT University

Leith H. Campbell
School of Engineering, RMIT University

Abstract: In this paper, through the replication of a pre-COVID-19 research project, we seek to test and compare first-year Australian university students' study and private uses of technology; compare the desires and capacities of different cohorts (Law and Justice vs Engineering) for technology use; and identify any impacts arising from COVID-19 to their learning experiences. Quantitative and qualitative data, collected by an online questionnaire, identified that, while some participants had more experience with different technologies, there were limited differences between the cohorts' willingness to use, and their use of, technology for study purposes. Concerns expressed by participants related to where, when, and for what purpose technology was used. Participants all had access to a smart phone, and almost all used a laptop for study purposes. The results suggest the combination of online or pre-recorded lectures and synchronous (either face-to-face or online) tutorials was the most favoured option. While participants were comfortable with the use of technology in teaching and learning, they were wary about using such tools for private communications; however, Zoom and Microsoft Teams, appeared to be in common use. The results confirm the need for a broader and more in-depth understanding of students' technology uses, needs, and desires.

Keywords: technology, digital literacy, COVID-19, e-learning, mixed methods

Introduction

This paper seeks to understand university students' current engagement with technology for study purposes in comparison with their private uses. Previously, when Queensland University

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of Technology (QUT) sought to harness expanding student use of smart devices for course delivery, a pre-COVID-19 study sought to gauge the effectiveness of QUT's law and justice students' use of technology for learning purposes (2013 Survey). Many other universities also were focussed on technology adoption to aid course content and information delivery, including by teleconferencing (Abbasi & Stergioulas, 2011); podcasts (Kidd, 2011); and other online systems (Jurado, Redondo & Ortega, 2012). The 2013 Survey confirmed QUT students' conservative use for study purposes (McNeill, Diao & Gosper, 2011); and a separation between personal and study uses (Dahlstrom, Walker & Dziuban, 2013; Cradduck, 2013).

Technology's use to enable university course content delivery, and of self-directed learning (Morris & Rohs, 2021), has increased. However, not all uses, or technologies, are effective in supporting learning (Hornik, Johnson & Wu, 2007); nor does "availability … translate to extensive use or access by students for learning purposes" (Bustillo-Booth, 2021). COVID-19 campus closures resulted in a shift to online learning. This created a new learning environment as many universities provided online learning for the first time, which constrained some students in their desire or ability to engage with academics and peers, and potentially impacted their learning (Yazgan, 2022). The need to engage more with materials also increased student workloads and adversely impacted upon time management.

The current study (2020-21 Survey), utilising constructs developed from studies found in the literature and the technology acceptance model ('TAM') (Davis, 1989; Davis, Bagozzi & Warshaw, 1989), builds upon the 2013 Survey. It engages in a cross-discipline comparison; and seeks to identify COVID-19's impacts on students' engagements, and whether they believed available technology was effective for remote and self-paced learning. It commences by overviewing relevant literature and describing the methodology. It then analyses 2020-21 Survey responses, presenting similarities and differences between cohorts; and comparing the law and justice (L&J) responses to 2013 Survey data. It closes by discussing implications for teaching practices.

Literature Review

The major themes in extant literature can be clustered into three main and interrelated categories. Noting the plethora of relevant discussion, the following engages with only some of the more recent literature, as directly relevant to our work.

The introduction and use of technology for teaching and learning

Technology use drives both innovations in technology, and the desire for more and better technology to use. Previous work considered student perceptions and uses (Nelson, Kift & Harper, 2005); managing technology distractions (Matthew, 2012); and the role of lectures in

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supporting students (Tanaka, 2012). More recently, Moreira & Rocha's (2017) special guest editorial on new technologies and the future of education and training identified mobility, wearable devices, and artificial-intelligence-driven Massive Open Online Courses (MOOCs), as key drivers of future improvements. They also identified teaching-learning process can become more reliable as new technologies for education and learning make access to information and communication more practicable. Souabni, Saâdi & Ben Ghezala (2019), who undertook a study into situation awareness from a ubiquitous learning system perspective, developed a multidimensional framework for situation-aware u-learning system that was used to evaluate research identified in the literature with the aim of improving outcomes. More recently, Peña-Ayala (2021) developed a learning design cooperative framework harnessing technologies to create a 21st century education setting. This showed improved balanced learning outcomes through framework use.

Yuan *et al.* (2021) extended the mobile technology acceptance model, by considering the influence of both pedagogy and technology on learners' compulsory m-learning experience response. Their results show learning content quality, user interface, and system connectivity affect the perceived usefulness of mobile learning, which in turn affects the experience response. Goksu's (2021) comprehensive bibliographic analysis, utilizing 5167 studies in the Web of Science database, found in the period 2015-2019 trend topics "were broadly that of educational technologies, and, more specifically, tablets, mobile phones, MOOCs and learning strategies" (Goksu, 2021). Successful research that featured prominently included augmented reality, higher education, and smartphone-oriented learning. However, as others considered, the move to online delivery during COVID-19 has had varied impacts on students' satisfaction with their courses (Alzahrani & Seth, 2021; Amponsah, 2021; Jiang *et al.*, 2021).

Attitudes to and acceptance by students of technology

The form of content delivery can also affect acceptance of the delivery mechanism. As McNeill, Diao & Gosper (2011) identified, students can be conservative in their use of technology. However, use is influenced by, and depends on, the purpose for that use. O'Sullivan (2018) used qualitative data from a small survey (88 participants) at an Irish university to attempt to identify platform preferences for academic reading, and how students' preferences were formed. While limited due to the number of participants, this identified there was a requirement to cater for a broad range of needs, including the continued provision of physical learning materials. In an empirical study of people between 16 and 24 years old, carried out to investigate the teaching of information and communications technology in universities as a cross-training curriculum topic, Picatoste, Pérez-Ortiz & Ruesga-Benito (2018) identified the necessity to provide self-training or informal personal training channels to meet their needs.

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Hamidi & Chavoshi (2018) carried out a study into the adoption of mobile learning in higher education. This aimed to evaluate the essential factors for the adoption and application of an education information system developed for the study. The factors identified were classified into seven categories – ease of use, trust, characters and personal qualities, context, perceived usefulness of using, behavioural intention, and culture of using a research model. Hamidi & Jahanshaheefard (2019) then considered student satisfaction, and internal and external factors. They noted universities are particularly interested in student satisfaction and, with a growing dependence on electronic learning, have raised the importance of mobile learning outcomes. They identified a strong link between mobile learning and positive student satisfaction.

Baragash & Al-Samarraie (2018) investigated different modes for delivering learning materials, and how peer connections related to higher education teaching and learning practices. An analysis of 196 questionnaire responses revealed student engagement in face-to-face learning positively impacts engagement when using learning management systems and web-based learning. Ifinedo, Pyke & Anwar (2018), studying usability factors on how undergraduates used Moodle in a blended learning environment, found, from 126 survey responses, usability factors have positive effects on student use.

Ali *et al.* (2020) studied the relationship between quality of life and access to information and communication technology by using simultaneous equation models. Their findings imply supply issues and demand strategies that include enhancement of digital skills and affordability should be emphasized by policymakers. Nam & Jung (2021) provide insights into users' digital content consumption trends by studying short-form digital content consumption, which is participative and multi-tasking. Laddering interviews were carried out and outcomes presented using a hierarchical goal map. This identified 14 goals (acquiring information, gaining insights, empathy, socialization, killing time, fantasy, fun, restorative, sharing information, escapism, curiosity, psychological stability, belongingness, sense of accomplishment) and four attributes (ubiquitous, trendy, entertaining, and concise) related to the 'snack culture'.

The effects of access and skills on student success

The ability to, and quality of, Internet access are equally important in determining student outcomes. In a study exploring Internet usage and communication competence, Lee, Park & Hwang (2015) found significant differences between consumer groups with "different network connection types across demographic lines, different levels of Internet usage, and different communication competences", with access and skill gaps being barriers to active engagement in online activities. These have an overlapping effect on the digital divide, the concept of

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unequal access to digital technologies and broadband, and how this affects digital competencies and choices (Horn & Rennie, 2018; Gunkel, 2003; Van Dijk, 2006).

Alam & Mamun (2017) studied the causal effect of household access to broadband Internet on individuals' labour market outcomes in an Australian rural and regional context, but found the causal effect was not statistically significant. However, in a study in rural Ohio, Khan *et al.* (2020) found demographics, Internet access, and digital skills can shape online contributions to the community, particularly for health, employment, education, and social media. Chakraborty *et al.* (2018) used a predictive model to measure the impact of fibre-optic broadband speeds on communities. They found it is possible to identify the differing economic impacts related to town size and local geographies as regards the broader benefits of broadband infrastructure. While each town is different, "broadband expansion" has "great potential to improve" economic conditions (Chakraborty *et al.*, 2018). People's attitudes, the Internet of Things, and skills are important factors affecting acceptance and use (de Boer, van Deursen & van Rompay, 2019).

Arpaci, Al-Emran & Al-Shafiri (2020) used a cross-cultural comparison of 380 Malay and 160 Turkish engineering students to study digital skills, knowledge management practices, and the acceptance by engineering students of MOOCs. This showed knowledge management practices, including access, storage and application, positively impact perceived usefulness; and knowledge sharing positively and significantly impacts perceived ease of use. Hampton *et al.* (2021) studied Internet access, digital skills, and media use related to rural student outcomes. They considered standardized exams ('SAT') outcomes, and a survey of rural Michigan students in grades 8-11; and found rural students with home broadband Internet access were more focused on schooling, completed homework more often, and achieved higher SAT grades.

Aydin (2021) undertook a study to identify the variables now causing the digital divide, utilising a sample of Korean and Chilean students taken from the participating countries of the International Computer and Information Literacy Study. The socio-demographic characteristics of the students was examined in the context of ICT literacy. This found two factors significantly affecting student outcomes were the parents' level of education (Chile), and Internet connection (Korea). As Arslantas & Gul (2022) confirm, for students with any level of impairment – visual considered by those authors – additional support may be required to enable the requisite level of digital literacy as well as access. Ensuring the educators have the necessary skills will be critical to supporting those students, as is the need to ensure adequate access; and for universities to enable students in their engagements with course material.

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Methods

This is a mixed methods study, involving a literature review and analysis of quantitative and qualitative survey data (Leech & Onwuegbuzie, 2009; Creswell & Plano Clark, 2017). The ultimate structure of the study utilised the technology acceptance model ('TAM'), a theory modelling interaction between users and technology, including how users come to accept technology and put it to use (Davis, 1989), with a focus on the effectiveness of the technology during COVID-19 to carry out remote and self-directed learning.

Charness & Boot (2016) describe TAM as "one of the most influential models of technology acceptance, with two primary factors influencing an individual's intention to use new technology: perceived ease of use and perceived usefulness". Mois & Beer (2020) note TAM is "one of the most prominent models of technology adoption"; and Schöpfel & Azeroual (2021) posit it is the "most influential, most tested, and best-operationalized approach". TAM describes actual system use as the point where individuals accept and use a technology. Behavioural intention (BI) is the factor leading individuals to use the technology. Users' attitudes (general impression of the technology) (A) influences BI. Other influencing factors include social influence and organisational influence.

This study focuses on two TAM factors influencing technology acceptance and use:

PU: the degree to which a person believes using a particular system would enhance their job performance; and

PEOU: the degree to which a person believes using a particular system would be free from effort (Davis, 1989).

Procedure

The study sought to understand and correlate technologies' effectiveness to TAM PU. It was delivered in two overlapping stages:

Stage 1 engaged with relevant literature. This noted the over-riding emphasis promoting the notion that technology is important for improving student learning outcomes. However, this is predicated on the belief students' engagement with technology for entertainment and social media correlates with their desire to engage with technology for learning purposes.

Stage 2 delivered the 2020-21 Survey, sought to test extant literature, and to specifically address TAM PEOU. A questionnaire[i] was developed containing a mix of Likert-scale, multiple-choice, and open-ended questions. Key Survey was used for data collection. Recruitment emails were sent in approximately semester week four, and reminder emails sent

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approximately five to six weeks later. Incomplete surveys, where participants did not click to submit, were excluded from analysis.

The 2020-21 Survey replicated and expanded the 2013 Survey, by including many of questions it asked; and delivering it to the same cohorts at QUT; and by including questions relevant to Internet access and different cohorts at RMIT University (RMIT). The 2013 Survey, delivered during July-August 2013, sought to test assumptions about student's technology engagements (Prensky, 2001; Barnes & Tynan, 2007). Results, while constrained by limited participants (98; only 92 were usable for current purposes), were consistent with then extant literature.

Participants

Potential participants were identified by enrolment status. The selected cohorts were QUT's law and justice students; and RMIT's law and engineering students; who were in their first semester of university study in semester 2 (July to November), 2020 or semester 1 (February to June), 2021. For analysis purposes, noting similarities between law and justice (L&J) programmes' delivery methods, responses from those participants are considered collectively. During the project, QUT's students were able to attend campus and had the option of in-person classes; RMIT's students were unable to attend campus due to lockdowns.

In 2020-21, participants identified as being female 51%, and male 46%; with 3% preferring not to identify. L&J students were predominantly female (74%) and Engineering students were predominantly male (72%). The L&J participant demographics were similar to 2013 participants: female 70%; male 28%; with 2% choosing not to identify (Table 1).

Table 1. Participant Demographics

	Female	Male	Prefer not to identify
2013 Survey	70%	28%	2%
2020-21 Survey			
L&J	74%	24%	2%
Engineering	25%	72%	4%
Total	51%	46%	3%

Data analysis

The data from the two deliveries was combined and analysed on a question-by-question basis. Responses from the L&J and Engineering cohorts were compared against each other. Due to the limited number of survey responses, and the resulting small differences between cohorts, the Kolmogorov-Smirnov test (Chakravarti, Laha & Roy, 1967) was used to compare distributions of results.

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Limitations

The project had five limitations.

Limitation 1: The project originally was to be undertaken in a normal environment: RMIT's students would be on campus; and QUT's students would be a mix of on-campus and online, thus providing distinct responses from on-campus vs online cohorts for analysis purposes. COVID-19 lockdowns resulted in most participants being 'online' for the project's duration. This impacted data available for comparison.

Limitation 2: QUT's university-wide organisational restructure, resulted in one internal cohort not receiving invitations to participate in the 2021 delivery. This reduced the number of potential participants.

Limitation 3: It appears the invitation link was 'shared' with non-eligible students. Twelve participants identified as not undertaking any eligible degree and were excluded. This reduced the responses available for analysis.

Limitation 4: Only 115 usable responses (of 127) were obtained. The low response rate impacts data reliability. However, as reflected in extant literature (O'Sullivan, 2018; Ifinedo, Pyke & Anwar, 2018), a low response rate is still meaningful in furthering our understanding of relevant issues.

Limitation 5: The universities' normal delivery methods, which may attract students, may have influenced participants' experiences. QUT's delivery has always included distance or online delivery. RMIT's delivery has included using online materials.

2020-21 Findings

The analysis of the 2020-21 Survey is grouped according to the devices owned or accessed; participants' technological background; devices used in lectures; devices used in tutorials; study and personal uses; and COVID's impacts on lectures and tutorial formats. Qualitative responses are analysed separately.

Devices owned and/or accessed

To understand engagements, we sought to understand what devices participants owned or had access to, and which they would be prepared to use for their studies. All owned a mobile phone (Q7. Do you own a mobile phone?). Two participants – one L&J, one Engineering – indicated they did not own a smart phone (Q8. Is your mobile phone a smart phone?) but had access to a smart phone (Q10). We also asked what other smart devices participants owned or had access to, and which they used for study or learning:

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- Q9. Do you own any other electronic/smart devices?
  Tablet/iPad, Laptop, Desktop, iPod (with Internet), Other
- Q10. What are all the electronic/smart devices you have access to?
  Tablet/iPad, Smart phone, Laptop, Desktop, iPod (with Internet)
- Q11. What electronic/smart devices do you use for study/learning?
  Tablet/iPad, Smart phone, Laptop, Desktop, iPod (with Internet), Other

Almost all owned a laptop. The two students (1 L&J; 1 Engineering) who reported not owning a laptop, each had access to both a laptop computer and a desktop computer. Ninety-three percent of participants (L&J 90%; Engineering 96%) reported using a laptop for study or learning. Although all had access to a smart phone, only 47% (L&J 50%; Engineering 43%) used it for study or learning. Participants reported using a Tablet/iPad for studying or learning 21% (L&J 11%; Engineering 10%); and a desktop computer 30% (L&J 35%; Engineering 25%).

We also asked about device preferences:

- Q37. If you had access to a smart device, would you use it for study/learning purposes? Yes–always, No–never, Sometimes, Maybe, Unsure
- Q38. If you had access to an electronic/smart device for study/learning purposes, which device would you prefer to use?
  Tablet/iPad, iPod (with Internet), Desktop, Laptop, Other

Participants used a device always or sometimes for study, if one were available. In total, 72% (L&J 76%; Engineering 67%) said they would always use a smart device and 25% (L&J 23%; Engineering 27%) said they would do so sometimes. These preference distributions are very similar (Kolmogorov-Smirnov statistic 0.08), with the perceived usefulness of smart devices largely supported by both cohorts (Figure 1).

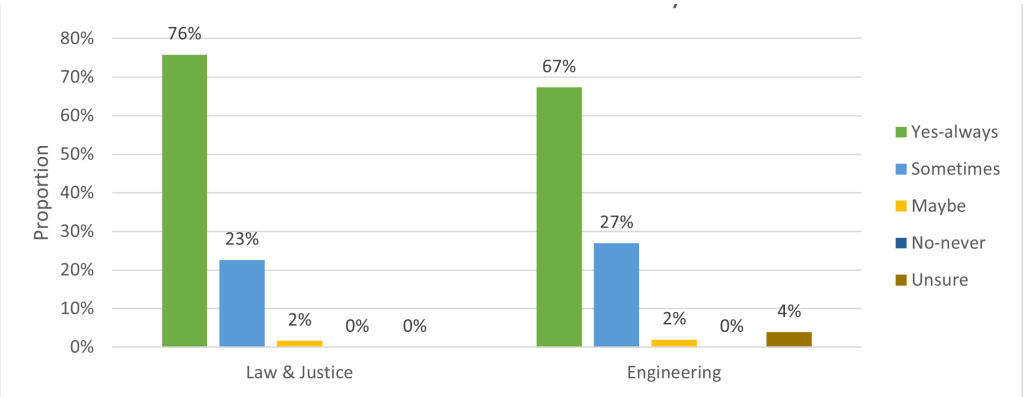

Figure 1. Preferences for use of smart devices for study

The laptop was strongly supported as the preferred smart device: 71% (L&J 76%; Engineering 66%). The desktop computer came next: 17% (L&J 15%; Engineering 21%), then tablets: 11% (L&J 10%; Engineering 13%). Again, the differences in preferences between the cohorts was

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small (Kolmogorov-Smirnov statistic 0.10). The results suggest the perceived ease of use of laptops and desktops – devices with large screens and physical keyboards – is greater than for other devices (Figure 2).

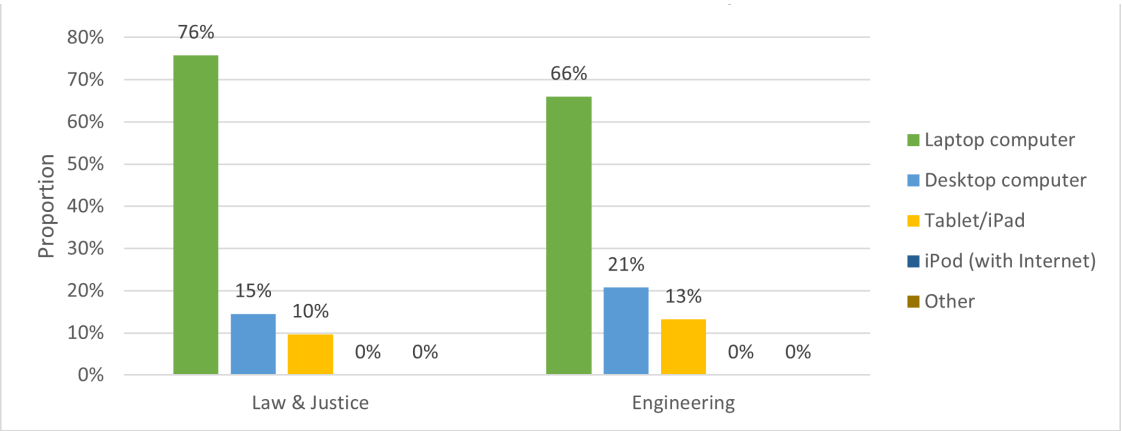

Figure 2. Preferred smart device for study

Students' technological backgrounds

To gauge prior (and recent) exposure to educational-related technologies, participants were asked to identify what they were doing on the same date last year. This was school 38%; university 23%; gap year 10%; working 25%; and other 4%. This is comparable to 2013 Survey participants (Table 2).

Table 2. Participant History

	School	University	Gap Year	Working	Other
2013 Survey	30%	27%	4%	27%	11%
2020-21 Survey	38%	23%	10%	25%	4%

To understand whether familiarity with a particular technology led to a more positive attitude towards its use, participants were asked about the use of smart devices in tutorials and face-to-face lectures:

- Q23. Please indicate the level to which you agree with the following statement – The use of electronic/smart devices in tutorials helps me understand the material presented.
- Q34. Please indicate the level to which you agree with the following statement – The use of electronic/smart devices in face-to-face lectures helps me understand the material presented.

For tutorials, the results are presented in Figure 3. Scoring the preferences numerically (*Strongly agree* = 2; *Agree* = 1; *Neutral* = 0; *Disagree* = -1; *Strongly disagree* = -2) and dividing by the number of responses gives very similar average results for L&J (1.12) and Engineering (1.12). Familiarity does not seem to lead to greater acceptance. The Kolmogorov-

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Smirnov statistic calculated from the L&J and Engineering preference distributions is 0.05, suggesting the two cohorts are quite similar.

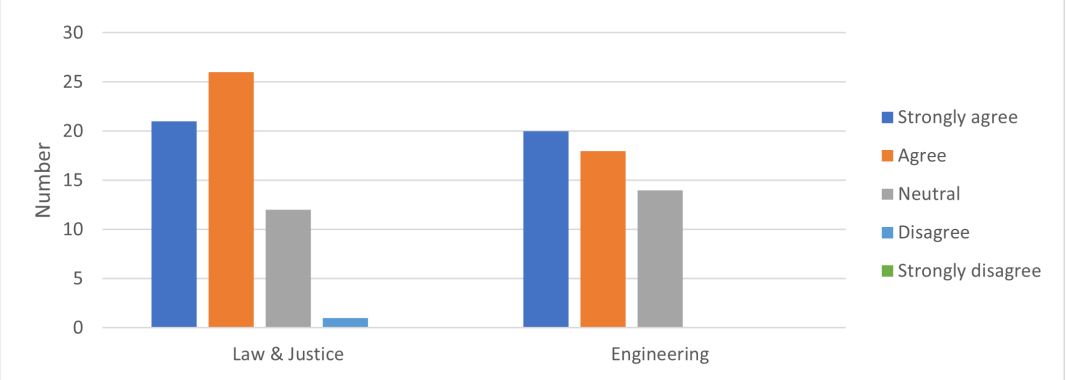

Figure 3. Strength of preference for use of technology in tutorials

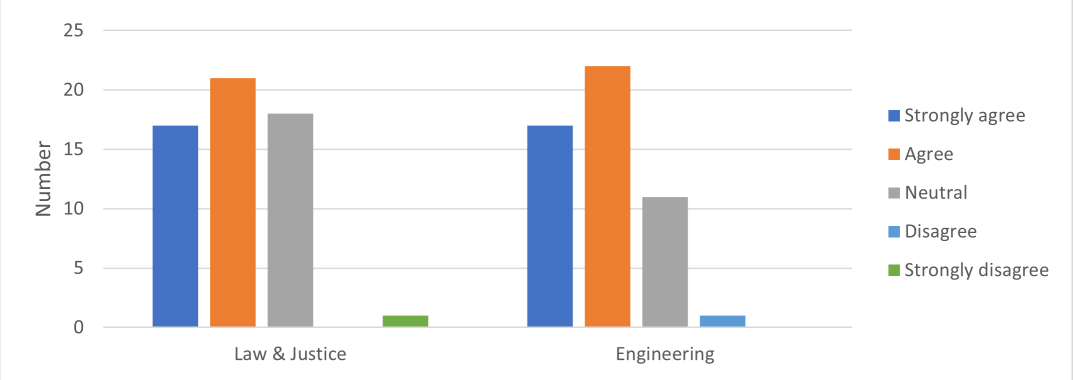

Figure 4. Strength of preference for use of technology in face-to-face lectures

The results for face-to-face lectures are depicted in Figure 4. Using the same scoring scheme gives more separated average results: L&J 0.93; Engineering 1.08. The Kolmogorov-Smirnov statistic between the L&J and Engineering distributions is 0.10, suggesting the cohorts are less similar in the lecture-preferences than in their tutorial-preferences case. The differences, however, may be influenced by course materials. The team's own experiences are that engineering lecture materials may more naturally lend themselves to more direct technological demonstrations, leading to increased technology use by lecturers.

Use in lectures

Participants were asked about their smart device use during lectures, and whether they took hand-written notes:

- Q27. In lectures, do you use your electronic/smart device for study/learning? Yes–always, No–never, Sometimes, Maybe, Not applicable (if not attending face-to-face lectures)
- Q28. Please indicate the level to which you agree with the following statement – I use my smart device in lectures for personal purposes.

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- Q29. In face-to-face lectures or in listening to lecture recordings, do you use electronic/smart devices and also make notes by hand writing?
  Yes–always, No–never, Sometimes
- Q30. [Only for those answering No to Q29] In face-to-face lectures or in listening to lecture recordings, do you only make notes by hand writing? Yes, No.

Most who attended lectures (16% did not: L&J 18%; Engineering 13%) reported using their smart devices for learning during the lecture. Of these 80% (L&J 82%; Engineering 78%) always used their devices in lectures for learning; with 18% (L&J 14%; Engineering 22%) using sometimes; and 2% (all L&J) not using. Device accessibility, however, may be distracting as 16% (L&J 15%; Engineering 17%) strongly agreed they also used devices for personal purposes; and 35% (L&J 39%; Engineering 30%) agreed (Figure 5).

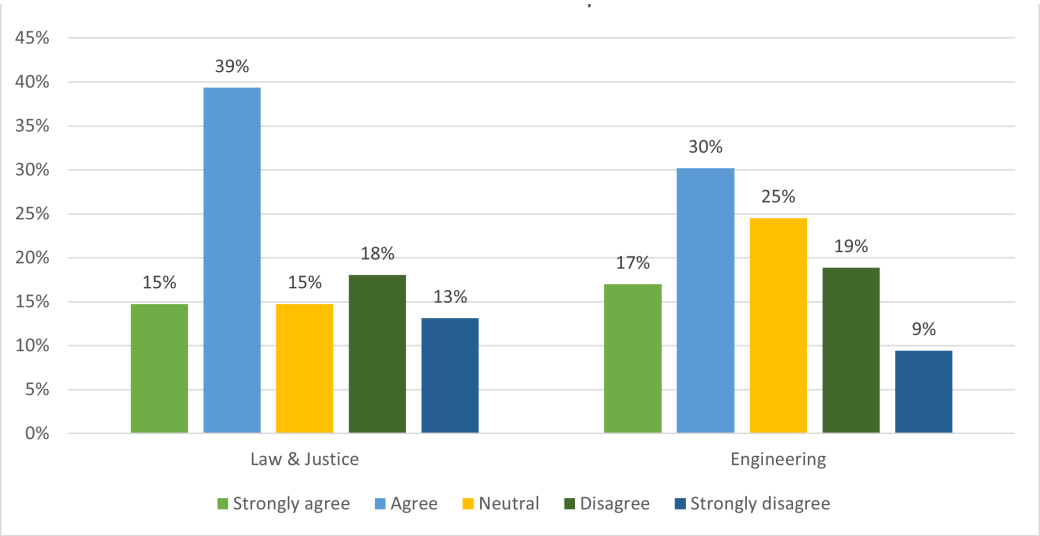

Figure 5. Use of devices for personal purposes in face-to-face lectures

While 23% (L&J 27%; Engineering 19%) said they used both devices and made notes by hand, none used handwriting alone. It appears handwritten notes are an adjunct to notes taken on a device.

Participants were asked to identify the devices and applications their lecturers used in face-to-face lectures:

- Q31. Do your lecturers use any electronic/smart device/s for teaching purposes?
  Yes–always, No–never, Sometimes, Not applicable (if not attending face-to-face lectures)
- Q32. What electronic/smart device/s do your lecturers use in class for teaching purposes?
  Tablet/iPad, Smartphone, Laptop, Desktop, iPod, None, Not applicable (if only listen to pre-recorded lectures), Other

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- Q33. What do your lecturers use the electronic/smart device/s to do in class? Powerpoint, Legislation, Blackboard, Canvas, Not applicable (if only listen to pre-recorded lectures), Other

Very few participants attended face-to-face lectures, and 37% (L&J 48%; Engineering 25%) reported only listening to pre-recorded materials. This reflects teaching rearrangements due to lockdowns. Where participants did attend, 95% reported lecturers used smart devices always or sometimes. The proportion was higher in Engineering (98%) compared to L&J (90%), presumably, again, reflecting the difference in material being presented. (Table 3).

Table 3. Proportion of Students Reporting Frequency of Use of Smart Devices by Lecturers

	Yes-always	Sometimes	No-never
L&J	81%	9%	9%
Engineering	93%	5%	3%
Total	88%	7%	6%

Laptop and desktop computers were very commonly used by all lecturers. Tablets were more frequently reported as being used by Engineering academics than L&J academics. iPods were not used (Figure 6).

PowerPoint use was a dominant use by lecturers: 89% (L&J 88%; Engineering 90%) reported lecturers using this application. Fifty-three percent of L&J students reported lecturers used devices to access legislation. The 3% of Engineering students reporting access to legislation may indicate access to engineering standards. The use of two main online teaching platforms, Blackboard and Canvas, was reported by 54% and 49% of students, respectively. The frequency of use was quite different between QUT and RMIT students, reflecting differing preferences in the two institutions' technology platform of choice (Figure 7).

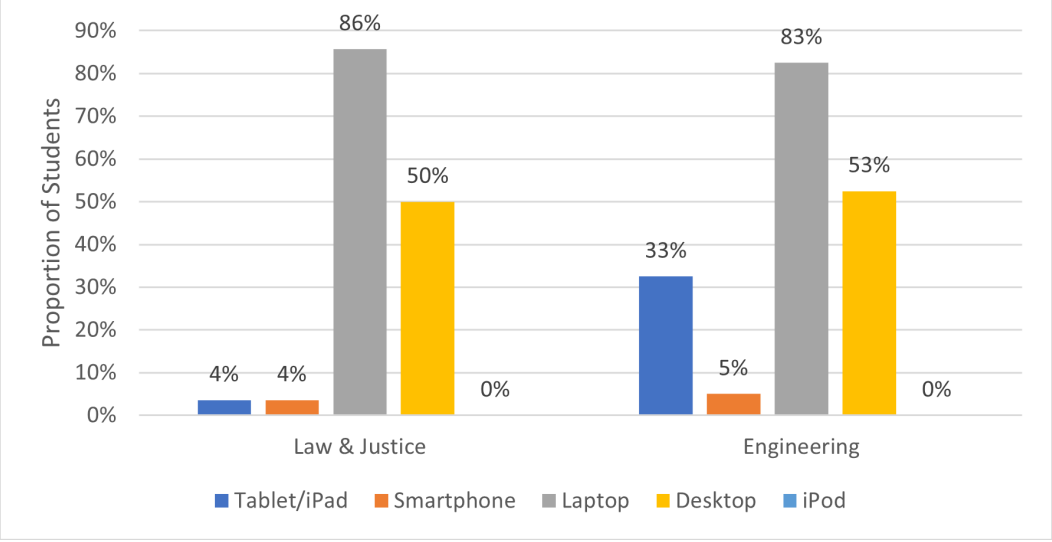

Figure 6. Proportion of participants reporting devices used by lecturers

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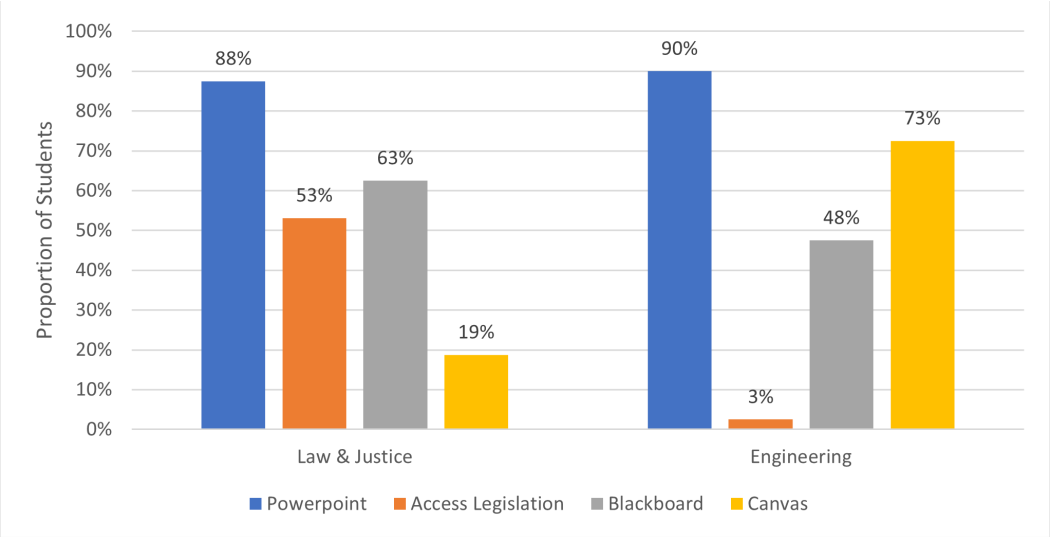

Figure 7. Proportion of participants reporting applications used by lecturers

Use in tutorials

It was assumed all participants were required to engage in tutorials. Participants were asked about device use in tutorials:

- Q16. In tutorials, do you use your electronic/smart device for study/learning? Yes–always, No–never, Sometimes
- Q17. Please indicate the level to which you agree with the following statement – I use my smart device in tutorials for personal purposes.
- Q18. In tutorials, do you use electronic/smart device/s and also make notes by hand writing? Yes–always, No–never, Sometimes
- Q19. [Only for those answering No to Q18] In tutorials, do you only make notes by hand writing? Yes, No.

For study purposes, 80% of students (L&J 79%; Engineering 81%) indicated they always used smart devices and 17% (L&J 15%; Engineering 19%) sometimes. Only 3%, all L&J students, indicated they never used a smart device in tutorials. The potential for devices to be distracting, while present, was comparable to lecture use: 14% (L&J 13%; Engineering 15%) indicated they strongly agreed, and 35% (L&J 34%; Engineering 36%) agreed, to use of smart devices for personal purposes in tutorials (Figure 8).

Handwriting notes in tutorials is slightly more common than in lectures: 30% (L&J 32%; Engineering 26%) indicated they never used both a device and handwriting and, of these, 15% (L&J 10%; Engineering 21%) used only handwriting. This means 4% of students (L&J 3%; Engineering 6%) use handwriting alone, as opposed to lectures when handwriting was never used alone.

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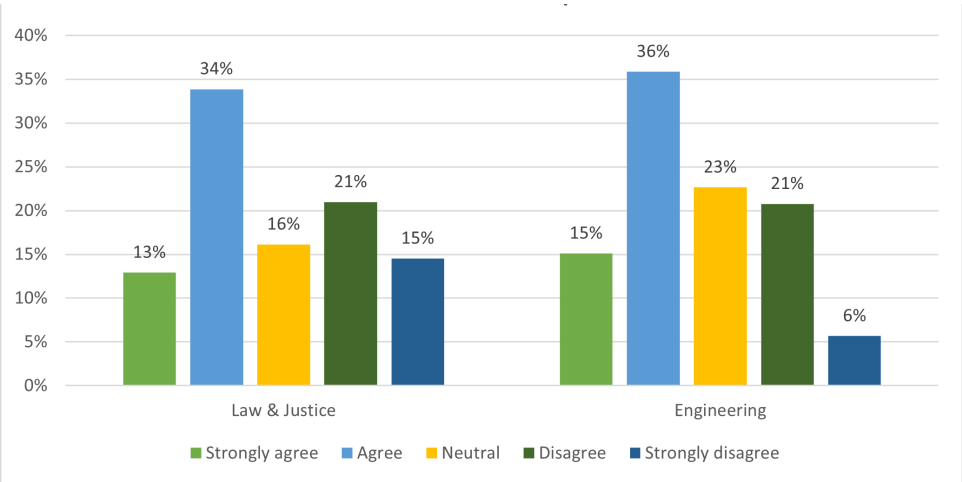

Figure 8. Use of devices for personal purposes in tutorials

Participants were asked how tutors used smart devices and applications in tutorials:

- Q20. Do your tutors use any electronic/smart devices in class for teaching purposes?
  Yes–always, No–never, Sometimes, Not applicable (if not attending tutorials)
- Q21. What electronic/smart device/s do your tutors use in class for teaching purposes?
  Tablet/iPad, Smartphone, Laptop, Desktop, iPod, None, Not applicable (if only listen to pre-recorded tutorials), Other
- Q22. What do your tutors use the electronic/smart device/s to do in class?
  Powerpoint, Blackboard, Canvas, Legislation, Accessing tutorial questions or materials, Not applicable (if only listen to pre-recorded tutorials), Other

COVID-related restrictions appear to have affected tutorial attendance: 10% (L&J 13%, Engineering 6%) reported not attending face-to-face tutorials. However, it must be noted many of QUT's first-year units provide students with the ability to attend a synchronous tutorial and access tutorial recordings. Participants who did attend tutorials, mainly reported tutors used smart devices always or sometimes (92%). The proportion was higher in Engineering (96%) compared to L&J (89%), again, presumably, reflecting the difference in material being presented (Table 4).

Table 4. Proportion of Students Reporting Frequency of Use of Smart Devices by Tutors

	Yes-always	Sometimes	No-never
L&J	65%	24%	11%
Engineering	80%	16%	4%
Total	72%	20%	8%

As in lectures, laptop and desktop computers were commonly used by tutors. Tablets were more frequently used for Engineering than L&J, and iPods were not used (Figure 9).

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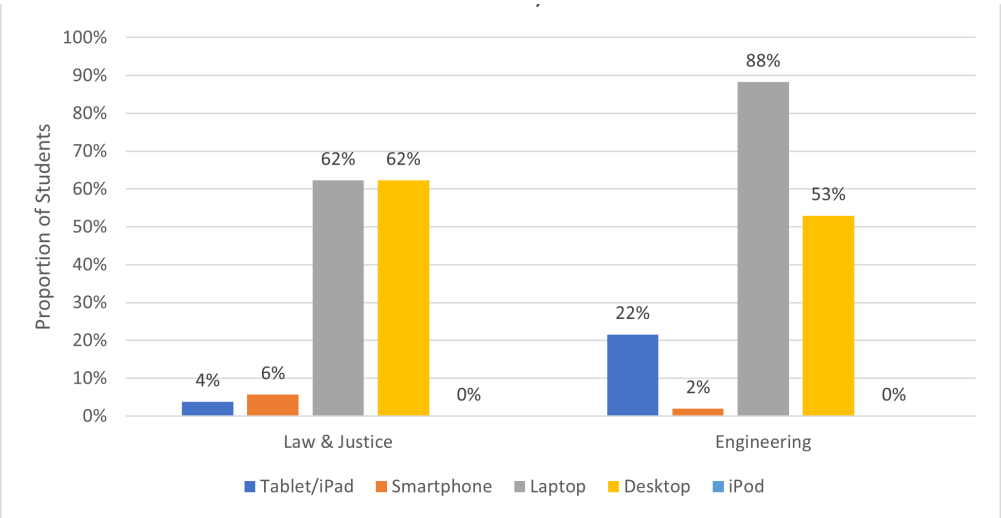

Figure 9. Devices used by tutors

PowerPoint was a dominant application: 80% (L&J 75%, Engineering 84%) reported tutors' use. The two main teaching applications, Blackboard and Canvas, were reported to be used by 48% and 43% of students, respectively. What tutors accessed differed: 60% of L&J students reported tutors used devices to access legislation. No Engineering student reported legislation access (Figure 10).

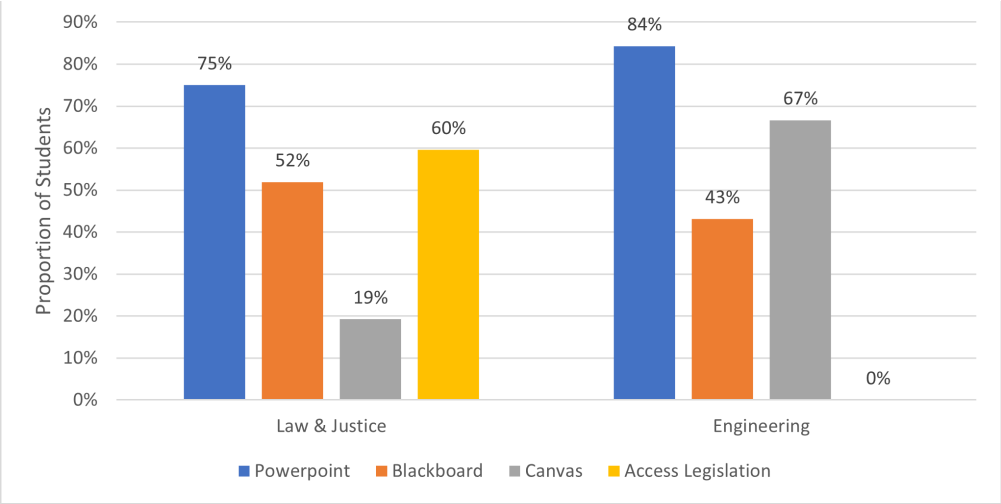

Figure 10. Applications used by tutors

Differences between study and personal use

We asked participants about the common applications used for teaching:

- Q40. I have used the following systems for study/learning purposes: Blackboard, Canvas, Echo360, Zoom, Collaborate Ultra, Teams, Other.
- Q41. I feel comfortable to use the following for study/learning purposes: Blackboard, Canvas, Echo360, Zoom, Collaborate Ultra, Teams, Other.
- Q42. I feel comfortable to use the following for private/personal purposes: Blackboard, Canvas, Echo360, Zoom, Collaborate Ultra, Teams, Other.

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- Q43. What additional support do you need so that you feel comfortable to use the following technology?
  Blackboard, Canvas, Echo360, Zoom, Collaborate Ultra, Teams, Other, No additional support required; I feel comfortable in using all of the above, Support required.

The responses uncovered significant differences between how the cohorts viewed these applications for study purposes and for private use (Table 5). For those who had previously used an application, there was a high degree of comfort with using the application for study purposes. Of the applications listed, the one providing least comfort was Microsoft Teams (78%). This suggests participants have become familiar enough with the main teaching applications to be comfortable with their use.

Table 5. Reported Comfort Levels in Using Apps

Application	Used App and Comfortable to use it for Study Purposes	Comfortable to use App for both Study and Personal Use
Blackboard	92%	25%
Canvas	93%	28%
Echo360	87%	22%
Zoom	86%	83%
Collaborate Ultra	91%	26%
Teams	78%	62%

Source: Column 2: Q40 & Q41; Column 3: Q41 & Q42

In contrast, engaging with the results for comfort to use the apps for both study and personal purposes, the number of participants who reported being comfortable with an app for both study and personal purposes is considerably lower. Zoom proved popular, as 83% of participants reported being comfortable to use it for both purposes, probably because it is the app of choice for social get-togethers during lockdowns. Microsoft Teams also rated relatively well (62% combined comfort level), probably because of its widespread take-up in the corporate environment.

The others – Blackboard, Canvas, Echo360 and Collaborate Ultra – all had combined comfort levels below 30%. The reasons for any difference in use between these tools was not explored in the survey questions. Although these also are collaboration tools, being more identified with the education environment, unlike Zoom and Teams, it can be speculated these are not recognized as being of use in other settings. There may also be an underlying perception that users are not as in control of their data and usage when engaging with those tools.

Two engineering students also reported using Discord, which is a relatively new collaboration tool.

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COVID's impacts on lecture and tutorial formats

Participants were asked about lecture formats:

- Q24. How do you usually attend lectures?
  I attend synchronous lectures, I listen to pre-recorded lectures, I listen to recordings of synchronous lectures, I do not attend lectures.
- Q25. Did you attend or listen to a lecture/s today? Yes, No.
- Q26. What was the format of that lecture?
  Synchronous online lecture, Synchronous face-to-face lecture, Pre-recorded lecture, Recording of synchronous lecture.

Only 3% (L&J 3%; Engineering 4%) did not usually attend lectures at all. For those who did attend lectures, there was a preponderance of listening to pre-recorded lectures (Figure 11). This may indicate a true preference for this presentation format, or it may be driven by convenience for the students, or it may indicate a COVID-19 effect.

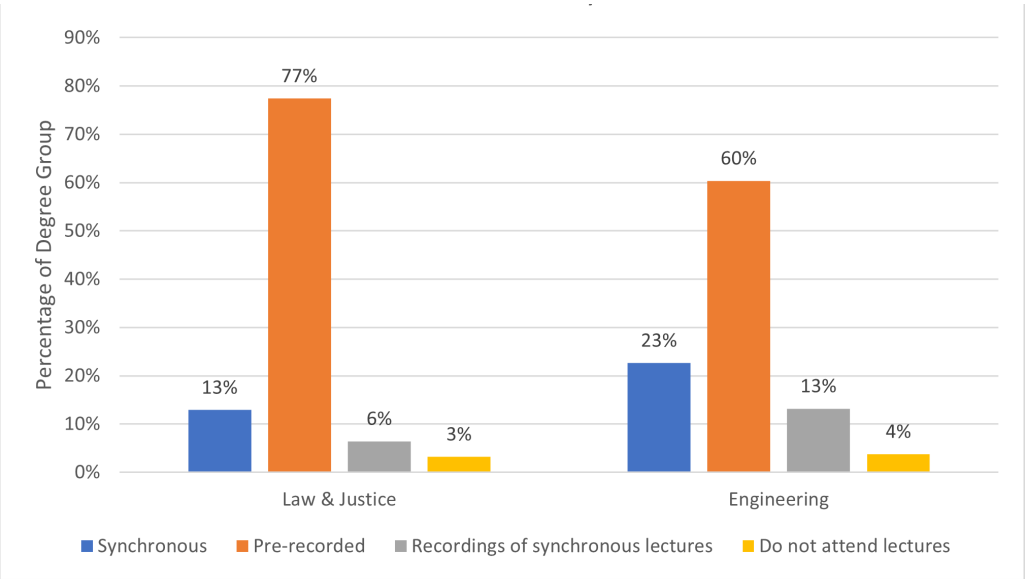

Figure 11. Reported lecture format usually attended

For those who attended one or more lectures on the day they completed the survey, the results were rather different (Figure 12). For L&J, there was mainly engagement with pre-recorded lectures. For Engineering, there was greater synchronous online attendance. This may indicate students prefer synchronous mode when it is online and convenient.

At both universities, because of COVID-induced rearrangements, there were few face-to-face lecture options available. L&J participants appeared to have preferred moving to only engaging with pre-recorded material, while Engineering participants showed a preference for the synchronous online format. However, comparisons with usual attendance should be treated with caution as participants had limited experience of university teaching.

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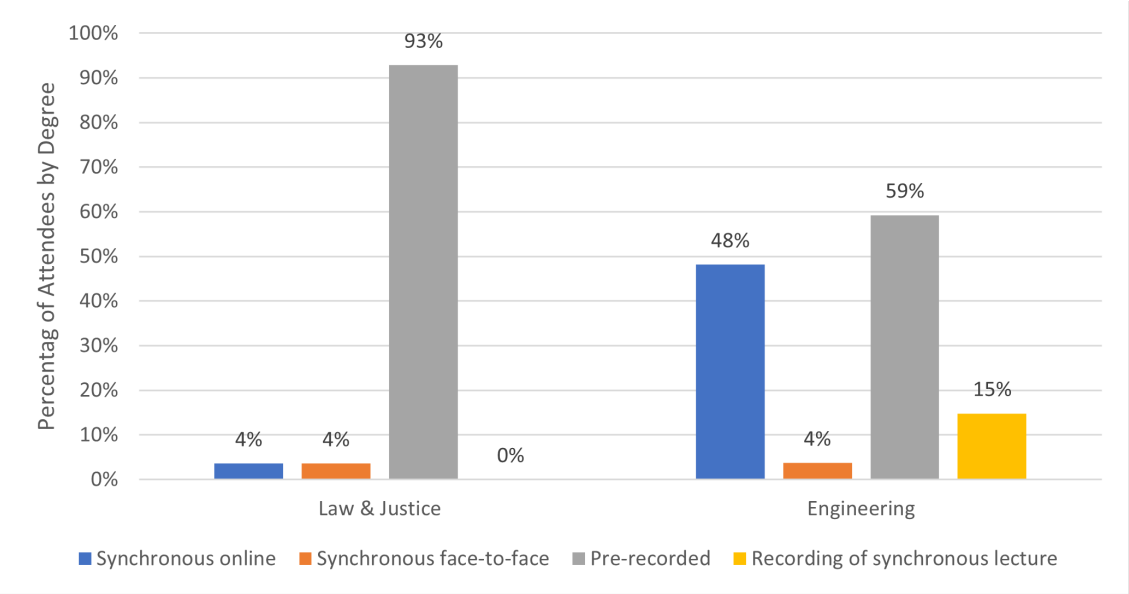

Figure 12. Reported format of lecture(s) attended on day of completing survey

We asked similar questions about attendance at tutorials:

- Q13. How do you usually attend tutorials?
  I attend synchronous online tutorials, I attend synchronous face-to-face tutorials, I listen to pre-recorded tutorials, I listen to recordings of synchronous tutorials, I do not attend tutorials.
- Q14. Did you attend or listen to a tutorial/s today? Yes, No.
- Q15. What was the format of that tutorial?
  Synchronous online tutorial, Synchronous face-to-face tutorial, Pre-recorded tutorial, Recording of a synchronous tutorial.

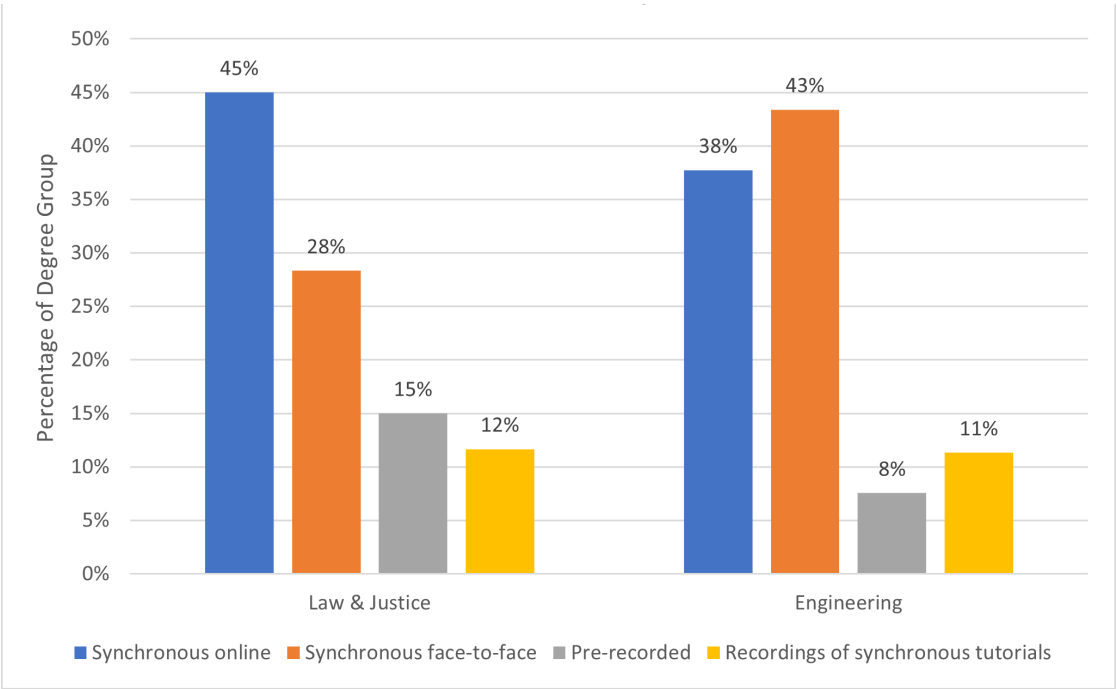

Figure 13. Reported tutorial format usually attended

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Two L&J students reported not attending tutorials, but most participants reported attendance, with a clear preference for (or, at least, practice of) a synchronous mode (Figure 13). The division between pre-recorded, and online or face-to-face, presumably depends on convenience and availability.

For those attending tutorials on the day of the survey, the results were relatively usual for L&J participants, but significantly more online for Engineering (Figure 14). Engineering participants had some face-to-face classes available, but many had converted to online.

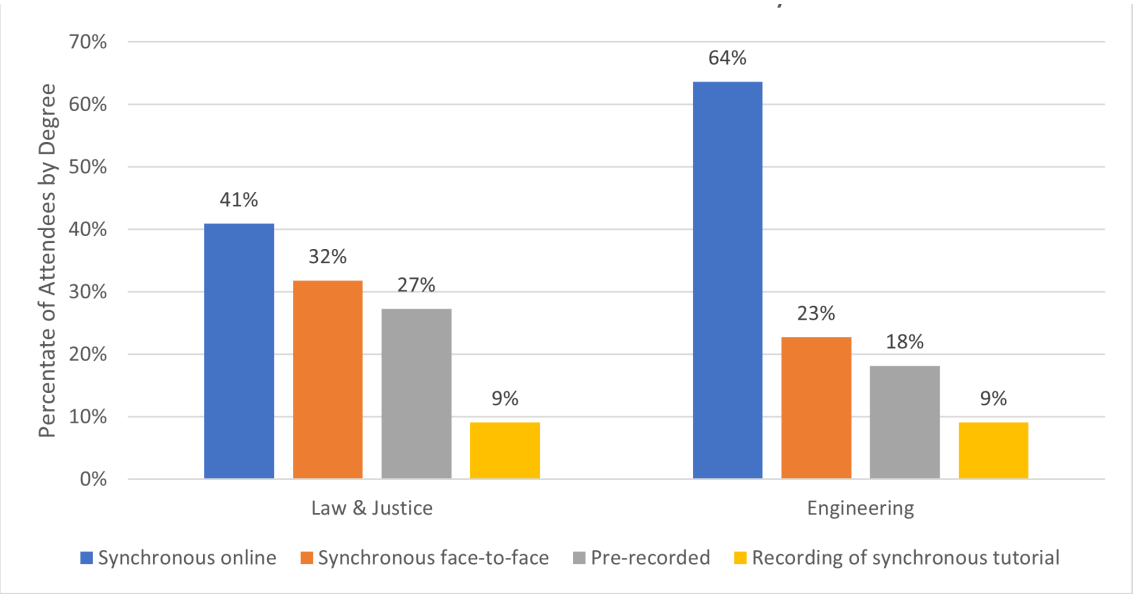

Figure 14. Reported format of tutorial(s) attended on day of survey completion

Overall, there is a common practice of listening to pre-recorded lectures, either out of study preference or convenience, with only 17% (L&J 13%; Engineering 23%) attending in some synchronous mode. In comparison, for tutorials the predominant practice remains a synchronous mode (77%), whether online or face-to-face. It appears also participants were able to move relatively easily to online format when the face-to-face option was suddenly taken away, as occurred when new lockdowns were announced.

Qualitative responses

Certain questions enabled participants to make free text comments: Q35, Q36 and Q37 yielded nothing useful, as most did not select the 'other' option; Q39 provided an opportunity for general comments; and Q43 specifically sought details of extra support needed for specific applications. Within the comments received, apart from general support for smart devices and technology, some themes were identified:

- Technology performance: complaints about slow Internet connections; complexity of or difficulties in using specific devices; and a lack of ability in tutors to use technology effectively.

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- Handwriting (perhaps triggered by earlier questions): comments both for and against the use of handwriting and the alternative of typing.
- Distraction: comments about how smart devices can also be used for personal purposes that may distract from study.
- Introductory guides: the need for, or the desirability of, how-to guides or introductory information on how best to use new applications.

One participant shared they had no hand function as the result of a spinal-cord injury, and, as such, was provided with a (human) notetaker by their university. The team thanks them for their openness. Their response is a salient reminder there will always be a proportion of students with limited physical ability to use smart devices, or interact with application interfaces, and for whom the human part of the technology equation is vital. In the broader context of engaging with available means to assist in "satisfying students' needs" (Chiu, 2021), it is important to remember that, for any student with any level of impairment, the additional support required will be more than merely digital (Arslantas & Gul, 2022).

Comparison to 2013 Survey

The 2013 Survey found all participants owned a mobile phone, with 95% of these being smart phones; and 89% owned a laptop computer, with 92% at least having access to one. However, while 89% of those participants utilised laptop computers for study purposes, only 43% engaged smart phones for this purpose. In-class use of devices for study purposes was limited (Cradduck, 2013). The combination of these results indicates the personal value of a device does not automatically correlate with its potential for enhanced learning.

There are clear differences between the 2013 and 2020-21 Surveys in preferences for using devices. On using smart devices for study purposes, the same question was asked in both surveys:

- Q37. If you had access to a smart device, would you use it for study/learning purposes? Yes–always, No–never, Sometimes, Maybe, Unsure

The difference in results, examined by engaging with L&J responses only, is shown in Figure 15 (cf. Figure 1).

These results reflect a shift in preference for use: in 2013, 89% of participants chose always or sometimes, which had increased in 2020-21 to 98%. The Komogorov-Smirnov statistic is 0.17, indicating the two distributions are substantially different. These results suggest the perceived usefulness of smart devices has increased over time.

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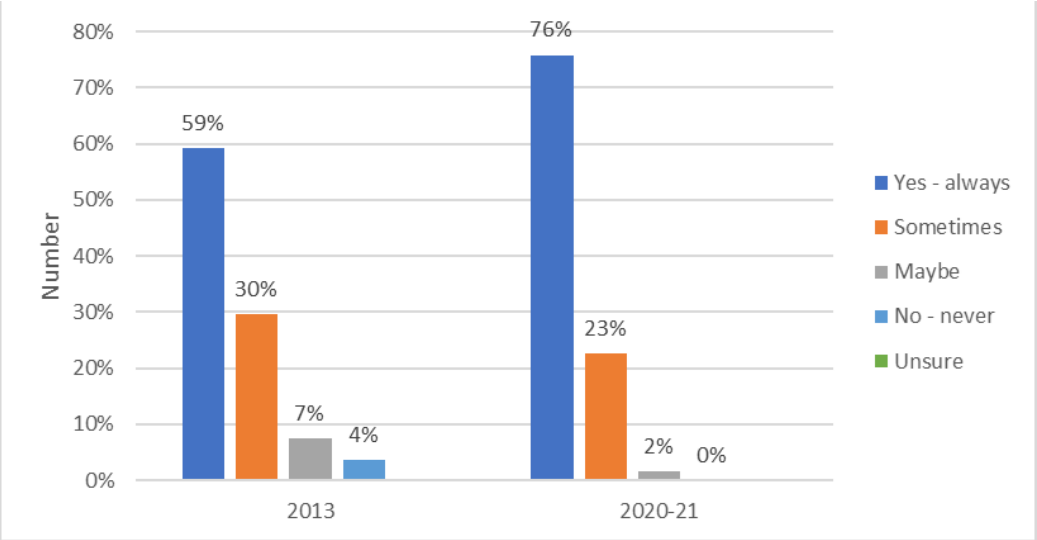

Figure 15. Comparison of L&J preferences for using devices for study

Concurrently, the level of scepticism appears to have grown regarding the perceived usefulness of academic use in lectures (cf. Figure 4). Both surveys asked participants:

- Q34. Please indicate the level to which you agree with the following statement – The use of the electronic/smart devices in face-to-face lectures helps me understand the material presented.
  Strongly agree, Agree, Neutral, Disagree, Strongly disagree

In 2013, 90% of participants strongly agreed or agreed to the proposition that the use of smart devices in lectures aids understanding; by 2020/2021, those responses had dropped to 67%. The Kolmogorov-Smirnov statistic is 0.25, indicating the two distributions are quite dissimilar. It appears familiarity in this case leads to greater discontent (Figure 16).

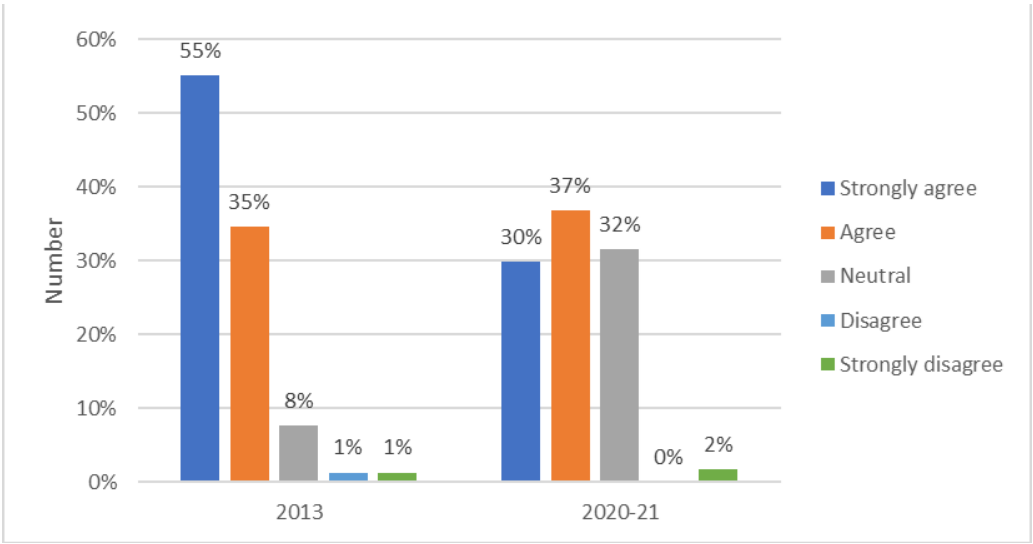

Figure 16. Comparison of L&J preferences for using technology in lectures

The picture is less clear in the perceived usefulness of using smart devices in tutorials. The comparative results for the same question about use in tutorials (Q23) are shown in Figure 17.

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There has been some shift towards greater acceptance: in 2013, 72% strongly agreed or agreed smart devices were useful in tutorials; in 2020-21, that proportion was 78%. The Kolmogorov-Smirnov statistic is 0.06, indicating the two distributions are quite similar.

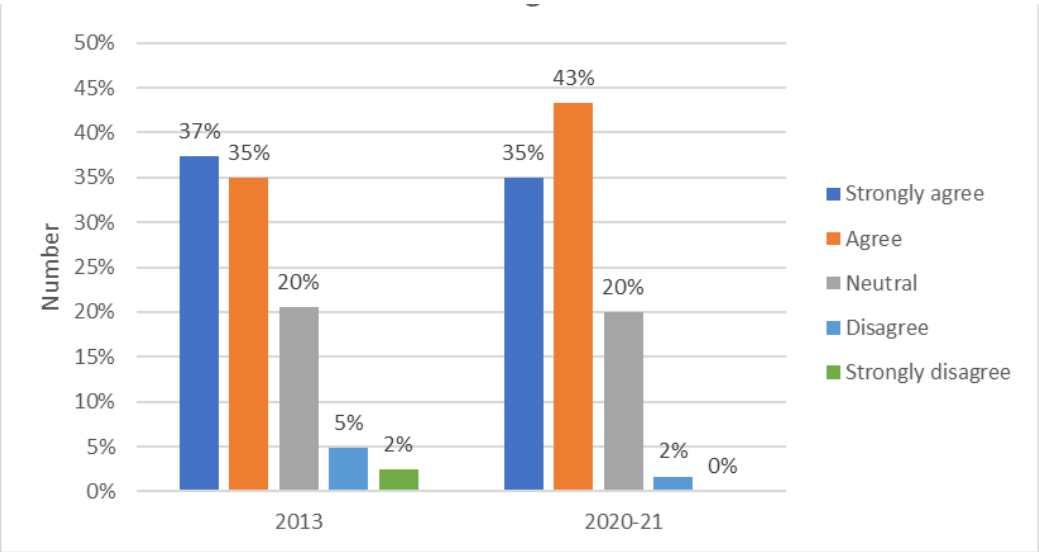

Figure 17. Comparison of L&J preferences for using technology in tutorials

Qualitative comments in the 2013 Survey support the quantitative findings, reflecting benefits gained from uses for learning purposes:

> "Using tablets are a great way to learn, especially in Lectures as you're able to view the powerpoint (if it's been posted) at your leisure and run over things there and then if you get confused, while also hand-writing notes".
>
> "Having a laptop and access to other devices makes it easy to access my learning resources".

This was consistent with 2020-21 Survey responses, which included:

> "Tablet is the best because you can both type and draw/handwrite digitally".
>
> "Research is easier and faster with an electronic/smart devices, and taking notes is also better through technology".

Other 2013 Survey participants identified concerns:

> "can often get distracted on the devices and therefore not pay attention to the lecturer or tutor and do not then fully understand the topic".
>
> "If cost of smart device and internet service is less expensive, I'll use more often and for wider purposes. Also concerned with battery life of device if used extensively."
>
> "I feel that it is imperative to write notes down while the lecture is taking place. My smartphone is too small to take notes on and my laptop too cumbersome. I will be

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> looking at purchasing a tablet form of technology for future study when the funds become available to me."

Some 2020-21 Survey participants identified similar concerns:

> "you have to be disciplined to not start using it for personal reasons and turn off notifications".
>
> "It'd be nice to have something to do handwritten working on. Taking photos of paper working is good and all, but it's stressful with a slow ass phone, that has issues with connectivity at times."
>
> "It's very hard as the screen is so small and requires holding the laptop for hours. Also the blue light... and there are often technological difficulties for the tutor. My classes are all around 5-8pm when my internet is slowest and it means that it frequently cuts out and I have to work out what I've missed."

Comparing 2013 and 2020-21 results indicates, while there were some concerns, smart devices support personal study and learning. Perceived usefulness in lectures and tutorials, however, is less clear. There is general support overall. However, support for using smart devices in lectures is waning, while, in tutorials, support is weakly improving. This warrants caution in introducing more technology into formal teaching, to best design the curriculum for engaged and enhanced learning purposes.

Discussion

The first research question sought to identify whether COVID-19 had changed students' engagement with technology when it is used for remote and self-paced learning. The 2020-21 Survey results reveal the answer is, overall, yes. In comparison to the 2013 Survey participants, proportionally more 2020-21 Survey participants identified as using devices for tutorial and lecture engagements. These results, however, are constrained by the fact that during COVID-19, when almost all university delivery was online, there was no alternative available.

The second research question sought to identify whether students believe available technology is effective for remote and self-paced learning. The results also reveal the answer to this question is yes. However, this also is qualified, as reflected in the qualitative comments, that some will require support in learning how to use the relevant systems; and others will require ongoing support (particularly regarding Internet access) in order to enable their use.

The 2020-21 Survey results highlight L&J and Engineering students appear equally engaged with their devices and technology for study and private purposes. There is a preference for listening to recorded lectures, but attending synchronous tutorials; and, not surprisingly,

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slow(er) Internet connections negatively affect students' ability to engage and therefore to learn. Importantly, perhaps arising from the universities' and or students' prior use/engagements with technology, issues relevant to emergency adoption measures in response to COVID-19, as seen in the impacts reported in other universities (Aguiler-Hermida *et al.*, 2021; Aguiler-Hermida, 2020), were not identified as being a concern for these cohorts.

What lessons can be drawn from these results for the approach to university teaching and learning? Although this is a modest project (O'Sullivan, 2018; Ifinedo, Pyke & Anwar, 2018), it spans two quite different disciplines, engages with university students facing differing direct impacts from COVID-19 (one university having to move completely online, the other being able to maintain a level of face-to-face teaching), and engages in comparison with data collected well before COVID-19 existed. The results from the 2020-21 Survey are consistent with extant literature, and also reinforce the 2013 Survey findings. As such, the current research adds to the literature and provides some useful general conclusions. The most obvious reflection is that most students now come equipped with at least the basic technology of a smart phone and a laptop computer. These devices, therefore, now can be assumed to be available; and, hence, are available to be used for learning purposes. Whether or not their use should be assumed for teaching is, perhaps, more problematical (McNeill, Diao & Gosper, 2011).

The 2020-2021 Survey results, however, show a clear difference in comfort levels for the use of certain applications for teaching or personal use. Applications that are not in widespread general use, such as Canvas and Blackboard, may be less acceptable if they intrude too much into students' personal activities.

On the other hand, the 2020-2021 participants appear to be confident in their ability to pick up and use new applications. No obvious skills gaps were identified in participants, with those who suggested support was required requesting a simple how-to guide to get them started. This suggests that less familiar applications should be able to be introduced with minimal guidance once trust in the application has been established.

Participants mostly all agreed technology has aided their learning in lectures and tutorials. There is some suggestion, however, that lecturers and tutors are not yet making the best use of available technologies. PowerPoint is a stand-out application, while specialized teaching applications are only identified in use by about half the students. While participants were reluctant to let teaching and learning activities intrude too much into their personal lives, they do let their personal lives intrude on teaching and learning, as a significant proportion reported using devices for personal matters during lectures and tutorials, which may be distracting from their studies. This is a feature to which pedagogy will need to adapt.

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There appears to be a clear, albeit not universal, acceptance of and engagement with synchronous online and recorded materials (Yazgan, 2022). As COVID-19 restrictions have lifted, this format may not be fully maintained in future. However, as students are discovering working from elsewhere is more convenient and efficient than attending campus, a level of pre-recordings is likely be a preferred option in the future. Importantly, for tutorials specifically, there is a clear preference for synchronous delivery, whether face-to-face or online. This supports the usual pedagogical view that interactions between students and with tutors is important for learning (Yazgan, 2022). Whether online or face-to-face tutorials are more effective is worthy of future study. Whether any continuation of online classes remains a reality only the future (and the constraints on universities) will tell.

Importantly, assumptions cannot be made about what any student's use will be, as the personal value of a device does not automatically correlate with its potential for enhanced learning. These findings reinforce the need to understand how students make use of technology for learning purposes, and to inform faculty staff on students' engagement of technology, to better design curriculum for engaged and enhanced learning purposes. Most importantly, the responses reinforce the fact each student is an individual deserving of individual attention and direct response to enable them in their engagements; and that students with any impairment will require additional support (Arslantas & Gul, 2022).

Conclusion

The 2020-21 Survey design was influenced by TAM (Davis, 1989), principally the two factors PEOU and PU. It was delivered across two diverse disciplines – L&J and Engineering – at two institutions to further understand student use of and preferences for smart, digital technology. Those results were compared with results from the 2013 Survey data.

Students by and large have embraced smart technologies, are confident in their use, and believe these add to the teaching and learning experience. In response to the COVID-19 crisis, Australian universities, including the two universities whose students were surveyed, generally had moved to online teaching. Participants seemed comfortable with this change, with the usual caveats about needing appropriate Internet connections and devices with suitable human factors. Synchronous tutorials, whether face-to-face or online, are still preferred, while there has been an acceptance of pre-recorded lectures.

In project planning it was expected students from a less technical background may be less enthusiastic about the use of technology in teaching. That expectation was not borne out, as data tended towards showing less technologically inclined participants were more enthusiastic about teaching technology. However, attitudes depended on where and when technology was

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used. There were, for example, greater privacy concerns when dealing with applications for personal use than in using the same applications for teaching and learning.

While most students can access smart phones and laptops, how much these devices should be used for teaching is still an open question. A more detailed examination of students' reluctance in certain engagements would be worthwhile. Indeed, as the whole landscape of students' background and familiarity with new technologies and applications is ever evolving, it would be beneficial regularly to survey students on experiences and attitudes to assist pedagogy to adapt and keep up with students' requirements and expectations. Future studies also could seek to understand the effectiveness of the various technologies used to deliver course materials to students, and students' perceptions of those technologies. This future work, for example, could expand from the current studies to understand the effectiveness, and responsiveness, of faculty members' in-class uses of those technologies through the lens of agentic engagement (Reeve, 2013).

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Endnote

[i] Ethics approval was obtained from QUT [approval number: 2000000531] and RMIT [approval number: 2020-23562-10938] prior to invitations to participate being sent. Potential participants were sent an invitation by their own university, and details were not shared. Participation was by informed consent and voluntary. Students self-selected to participate (or not); and were able to withdraw prior to submission. Consent was by clicking to submit.

Study on Fixed and Dynamic Spectrum Access Models for Cellular Networks

Muhammad Sheharyar
National University of Sciences & Technology (NUST)

Alamgir Naushad
National University of Sciences & Technology (NUST)

Imran Khan
National University of Sciences & Technology (NUST)

Muhammad Abid Hussain
National University of Sciences & Technology (NUST)

Faizullah Khan Kakar
Balochistan University of Information Technology, Engineering & Management Sciences (BUITEMS)

Abstract: Radio frequency spectrum is a scarce resource, hence its effective and efficient utilization for contemporary and future technologies is of paramount importance. This paper mainly focuses on analysing conventional models for spectrum management, such as command and control and market-based models, and their inefficacy to serve the upcoming technological demands globally. Generally outlined observations concerning spectrum mismanagement include lesser availability of unassigned spectrum and under-utilization of spectrum allocated to passive users. Due to the considerable urge for flexible spectrum assignment framework models and policies, new spectrum assignment approaches, such as Dynamic Spectrum Access, are investigated. Moreover, models such as Licensed Shared Access (LSA), which evolved from Europe, and Citizen Bands Radio Service (CBRS) from North America are also evaluated in this paper as potential choices for future spectrum management in Pakistan. In the aforesaid models, spectrum is shared among multiple users as per time, place and dimensions, keeping in view the security and priority of incumbent and licensed users. In addition, the efficiency of spectrum utilization and economic advantages of these models have also been analysed. Lastly, LSA and CBRS are studied comparatively, and spectrum management suggestions are made for effective implementation in Pakistan.

Keywords: Command and Control model, Market-based model, Dynamic Spectrum Access (DSA), Licensed Shared Access (LSA), Citizen Bands Radio Service (CBRS)

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Introduction

The radio spectrum is part of the electromagnetic spectrum, ranging from 1 Hz to 3000 GHz (3 THz). Electromagnetic waves in this frequency range, referred to as radio waves, have become widely used in modern technology, particularly in telecommunication. However, this paper is mainly concerned with the radio spectrum for cellular mobile. The International Telecommunication Union Radio Communication Sector (ITU-R) regulates radio spectrum to avoid interference among the radio spectrum users across the globe. Radio bands are typically classified into multiple frequency bands, and each band is reserved for a specific class of use. Within each band, users occupy different frequency ranges, transmitters, and guard bands to avoid interference. The capacity of wireless calls and data connections is all dependent on the available spectrum bandwidth. A small radio spectrum portion, within the available bandwidth, is incorporated in wireless products, such as mobile phones, terrestrial broadcast television and radio, satellite broadcasting, location systems like the Global Positioning System (GPS), Wireless Local Area Network (WLAN), remote control devices, and cordless phones. A major portion of the radio spectrum is allocated to or used by governmental and industrial areas, such as military and national security systems, satellite communication, maritime communication and navigation, aviation systems and weather radar.

Broadly speaking, the radio spectrum is divided into two bands, the licensed band and the unlicensed band. The licensed band refers to the spectrum which has been allocated to operators in a certain amount and for a certain time by a regulatory authority; it is utilized by the operators to provide multiple services to consumers according to the nature and application of the requirement, such as telephony, broadband and Internet Protocol Television (IPTV).

The Cellular Mobile Operators (CMOs) serve users through licensed bands, and hence the users pay for the services provided by the operators. Moreover, the licensed band sold by the regulatory authority to the CMO is deployed to provide multiple services, like voice over IP, broadband and multimedia communications. Through this procedure, the service users pay for the services provided by the CMOs. The unlicensed band is a small portion of spectrum that can be used by operators according to their needs without interfering with other licensed users, keeping in mind that certain regulatory requirements need to be attained, such as channel occupancy time, transmission power, and listen-before-talk mechanism (Saha, 2021). In some countries, the 2.4 GHz Industrial, Scientific, and Medical (ISM) band is used as an unlicensed band, while others use the ISM 5GHz band. The unlicensed band applications include free-to-access wireless technology, such as Wireless-Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WiMAX), Radio and Television.

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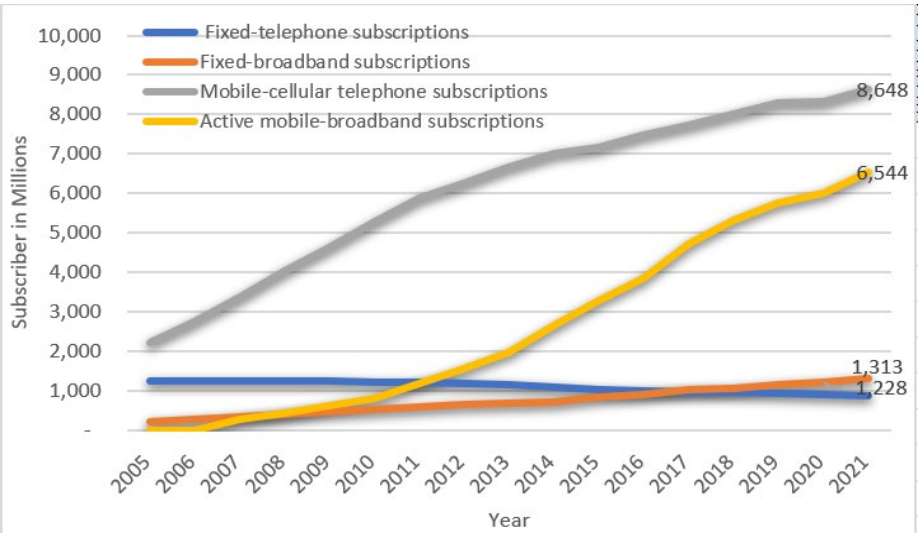

Figure 1. Global Trend of ICT developments, for Mobile cellular against other technologies (ITU, 2022)

Figure 1 illustrates that wireless personal communication has become the most widespread technology nowadays. The global number of active cellular mobile subscriptions reached 8.6 billion by 2021 (ITU, 2022). According to a forecast, there would be 8.7 billion handheld mobile devices worldwide and 4.4 billion machine-to-machine connections by 2023 with new data-hungry multimedia services, real time traffic data and 8K television (Cisco, 2020). Demand for radio spectrum is increasing with the number of wireless devices and bandwidth-consuming content: regulatory management of spectrum needs to ensure maximum social and economic benefit from the use of this finite and scarce resource (Radio Spectrum, 2015).

Multiple conventional approaches have been adopted to manage the scarce radio spectrum resource, such as the administrative Command-and-Control approach, market-based approach, and spectrum commons. The inefficacy of conventional models has led the market and attention of academia to dynamic frequency allocation models, such as Citizens Band Radio Service (CBRS) and Licensed Shared Access (LSA), for future management of radio spectrum and upcoming technologies.

Radio Spectrum Planning, Management and Regulation in Pakistan

Currently, in Pakistan, 189 million mobile users and 108 million Internet users, in mostly all fields of telecommunications, such as radio and television broadcasting, civil aviation, satellites, defence services and mobile communication, depend on radio frequency spectrum and its specified allocations. Under the standard framework, defined by ITU-R, the responsibility of further sharing and managing radio spectrum resources is shifted to the national regulatory bodies. The Pakistan Telecommunication Authority (PTA) is the national regulatory body for establishment, operations, and maintenance of the telecom sector (PTA, 2022a); whereas the Frequency Allocation Board (FAB) is responsible for radio spectrum

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assignment, and management (FAB, 2022a). Moreover, the Ministry of Information Technology (MoIT) is the government entity concerned with information technology and telecommunications for planning, policy making and legislation (MoIT, 2022).

Over the last decade, the usage of, as well as demand for, the radio spectrum has increased dramatically in the whole world. In this regard, Pakistan has faced a similar trend, and sees the same trend ahead, for further usage and demand, driven by growing data transmission rates, and increasing numbers of wireless devices, such as smartphones, laptops, tablet devices, and Internet of Things (GSMA, 2022). The demand for wireless broadband has also soared due to technological innovation, such as Third Generation (3G) and Fourth Generation (4G) mobile services, and now the upcoming Fifth Generation (5G) technology, and the rapid expansion of wireless Internet services that will further push the demand for effective spectrum requirements (Shaukat, 2015). On the administrative side, spectrum management is organized with proper spectrum planning, analysis, allotment, monitoring, and application, and re-enforcement of all rules and regulations of radio waves. The table of allocation is followed and updated by ITU-R, which is further revised at each World Radiocommunication Conference (WRC). National procedures for spectrum allocation can be summarized as:

- A table of frequency allocation maintained by the FAB is the initial draft that has been put in place for reviewing assignment and allocation to users with proper band and channel plans for spectrum management.
- The FAB receives applications (proposals include bandwidth, area of service and transmit power) from various departments, such as the Pakistan Telecommunication Authority (PTA), Pakistan Electronic Media Regulatory Authority (PEMRA) and governmental bodies, for assignment of radio frequencies. It assigns radio frequencies with proper technical parameters after technical evaluation on spectrum management tools and review of the frequency spectrum plan, while fulfilling national obligations, rules and regulations.
- Approval or disallowance of the relevant application in light of the decision by the Board is sent to PTA and PEMRA for license issuance or otherwise.
- While issuing the new bands, spectrum is made available as per Government policy and defined regulations.
- License Exempt spectrum will be made available after conforming with ITU-R radio regulations; devices should be approved and follow international and PTA standards ensuring non-interference (PTA, 2022b).
- Amateur wireless licenses are also issued to users who comply with the standard eligibility criteria defined by PTA (PTA, 2018).

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Pakistan, as situated in Region 3 and as a signatory to International Telecommunication Union (ITU) convention, is also following a conventional administrative and market-based approach for the regulatory framework all over the country. In this regard, the frequency spectrum allocated in Pakistan ranges from 9 kHz to 275 GHz for various applications, such as fixed, mobile, mobile-satellite (earth-to-space), radio astronomy, radio navigation, radio navigation-satellite, and space research, while 275 GHz to 3000 GHz is not allocated (FAB, 2022b).

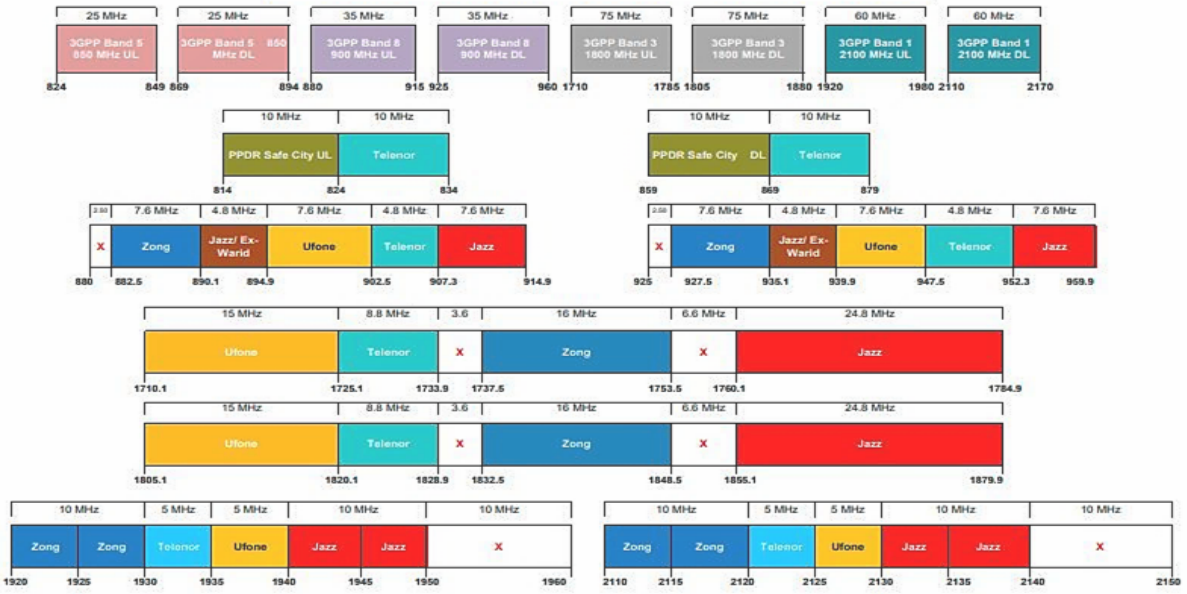

Figure 2. Cellular Assignment in Pakistan (Cellular Assignments in Pakistan, 2022)

Figure 2 presents the complete assignment of allocation frequencies for cellular services in Pakistan (Cellular Assignments in Pakistan, 2022). From this figure, it is clear that the assigned frequency bands allocated to the Pakistan-based Cellular Mobile Operators for downlink and uplink frequencies are: for 2G (850 MHz, 900 MHz); 3G (1900 MHz, 2100 MHz); and 4G (1700 MHz, 1800 MHz). It can be observed that most of the spectrum band is already occupied with the conventional spread spectrum techniques, and very little spectrum is left unconsumed to facilitate new technologies in the market, such as 5G, and, thereby, to allocate new spectrum bands, such as 2.3 GHz, 2.6 GHz, 3.5 GHz, and 700 MHz, to old and new service operators.

Conventional Spectrum Management

The need for new radio spectrum bands is ever increasing, which highlights the dire need for an innovative spectrum management model, as traditional approaches of spectrum management do not meet the futuristic requirements of upcoming technologies. The revenue generated by radio spectrum utilization is considered to be a strategic resource for the national economy worldwide. While surveying the introduction as presented in section 1 of this paper,

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it has been analysed that implementation of conventional spectrum management models for policy management, as well as in the technical domain, are not robust enough to cater for the demand of upcoming technologies, such as 5G services. The national and international bodies responsible for spectrum management are continuously making serious efforts to find a better way of handling the scarce spectrum resource (GSMA, 2017). Critically, if the spectrum resources are not properly managed, within the existing spectrum bands, the resources are going to become a pitfall for meeting the future demand of existing users and that of upcoming technologies and, due to this unforeseen situation, the old users may create a monopoly in the market. Therefore, policy management requires efficient and effective updates in the methods and approaches to re-assign the spectrum. In that sense, Pakistan is facing the same global issue of not adequately employing a robust framework for dynamic spectrum management and relying heavily on the conventional fixed assignment model that has resulted in spectrum scarcity with inefficient spectrum utilization, thus rendering minimal economic benefits.

Command and Control approach

The administrative approach, traditionally referred to as the command-and-control approach, is traditionally one of the dominant methods that regulators have used to manage the radio spectrum and is still effectively employed in some parts of the world today. The spectrum management is done through direct awards of radio spectrum licenses. In the authoritative control and command approach, the regulator will decide upon allocation and assignment of fixed frequency band usage rights for a specific use with respect to time, place and frequency. In this model, a user applies for a specific frequency spectrum range and the regulator assigns a non-overlapping frequency band to the user after performing legal procedures. If there is only one applicant, the services would be licensed on first come, first served basis; but, for more than one contender, the regulator will hold a public hearing or auction, which will determine the rights transfer to the successful applicant. However, obtaining the license does not provide property rights of the spectrum to the licensee, but confers enforceable rights with respect to fixed usage about purpose, frequency band, transmission power, and location. Command-and-control approaches generally do not permit license trading, which may produce better economic results and usage of the spectrum (Freyens, 2007). From the administrative point of view, there is neither a proper way for licensed users to observe and adopt market changes, and thus get more spectrum from regulators; nor do the regulators have unassigned bands to provide to the user and serve their robust demands (Matheson & Morris, 2012).

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Market-Based approach

The inherent limitation in the command-and-control approach paved way to the market-based approach, which replaced the administrative assignment in many countries. Through the idea of the newly introduced mechanism, a license is provided to those limited number of competitive market users who are eligible to own the license, for a specified period of time, and are capable of exploiting effective and efficient use of spectrum bands provided with the license. This approach weighs the radio spectrum more and takes into account the efficient use of spectrum bands held through license. Some countries and their regulatory bodies also managed to introduce secondary users and markets for spectrum trading, where the spectrum rights can be furthered via vending and leasing, concerning, particularly, about geography, bandwidth, and time. Trading and leasing of spectrum in secondary markets generally refer to the idea of an increase in efficient utilization of spectrum with scope for new entrants, working for social welfare and coping with the spectrum demands across different geographical areas, to the market (Kalliovaara *et al.*, 2018). The success of spectrum bargaining mainly depends on its trading cost that will justify economic efficiency as a parametric objective. Consequently, this pre-condition upscales complexity in spectrum management and technical prerequisites of spectrum management. This would ultimately create enough space for buyers and sellers to make the market competitive and, thereby, produce best public interest. Secondly, the complexity of spectrum utilization, such as assignment and handling spectrum among different users with no harmful interference, is adequately managed (Matheson & Morris, 2012).

Command and Control vs Market-Based approach

Table 1. Comparative Analysis of Command and Control and Licensed Shared Access

Aspect	Command and Control Approach	Market-Based Approach
Spectrum availability	With the fixed assignment of spectrum to CMOs, the scarcity issue arises with time in this approach. Spectrum sharing has been suggested to Spectrum shortcoming. (Shaukat, 2015)	Spectrum will be available to more users through market sharing and leasing (Prasad & Sridhar, 2013).
Spectrum usage	Assignment of large band spectrum to number of operators for fixed term is not reasonable due to underutilization because every operator cannot use spectrum efficiently due to a smaller number of subscribers (Kibria *et al.*, 2016).	Being even effective and economically industrious, but this approach cannot fully optimize underutilization due to minimal control of regulatory oversight.
Spectrum assignment	Spectrum assignment on unjustified prices with exclusive rights to use, which is clear example of injustice in the market (Prasad & Sridhar, 2013).	This approach applies auction and leasing to market users and sub-users for trading of spectrum at a fixed long interval (Prasad & Sridhar, 2013).

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Aspect	Command and Control Approach	Market-Based Approach
Spectrum license duration	Licenses are assigned for long period of time, such as 10 to 15 years. During this time period, no other user can use this spectrum band even if underutilized.	Spectrum license is awarded for 10 to 15 years of interval, which cannot be retained back after duration completion, but can be renewed.
Market competition	Market competition is not appreciated due to small number of operators, all with exclusive rights, and with no opportunity for new operators to get into the market (Prasad & Sridhar, 2013).	All market users are invited to compete for spectrum auction and trading (Shaukat, 2015).
Spectrum price	Government uses the spectrum auctions to boost revenue. However, due to non-realistic prices of spectrum trading, social welfare and public interest cannot be guaranteed; therefore, causing the firms to overbid the actual value of national assets. This is detrimental to the growth of industry (GSMA, 2014).	Spectrum price depends on the number of buyers and sellers in the market in addition to impact of price on spectrum availability (GSMA, 2014).
Spectrum access	Command and control approach gives exclusive rights to users, resulting in effective technical and allocation efficiency. In addition, regulatory bodies cannot maintain transparent information about the utilization of spectrum by the users (Prasad & Sridhar, 2013).	This approach renders exclusive rights to users, resulting in non-effective technical and allocative efficiency. In addition, regulatory bodies cannot maintain transparent information about the utilization of spectrum by the users (Mueck *et al.*, 2020).
Spectrum trading	The authoritative command and control approach does not allow spectrum trading to secondary firms; consequently, making the entry of small firms difficult in the sector, and the higher likelihood of suboptimal use of spectrum is disregarded (Prasad & Sridhar, 2013).	This approach allows spectrum trading to secondary firms; consequently, making the entry of small firms easy in the sector, and thus the chances of suboptimal use of spectrum are enhanced (Prasad & Sridhar, 2013).
Industrial growth	Government is mostly focused on accumulating high prices and revenues from operators. This becomes a trade-off for fast infrastructure growth of the industry.	This approach is mainly focused for a large number of operators, thus adding support to competitive and productive industrial growth.

Technical and economic impact of administrative and market-based model

Due to limited vacant spectrum availability, economic viability of administrative and market-based approaches is challenged progressively with time. These models do not provide adequate solutions to facilitate the required services for new applicants and users. It has been observed that the spectrum allocation, performed via conventional models, has resulted in the inefficiency and scarcity of available spectrum (Prasad, Sridhar & Bunel, 2016). Moreover, the radio spectrum bands, issued to users for long-term periods, cannot be recalled from the primary users within the allocated period. In comparison, the administrative approach is more biased towards monopoly of incumbents, while the market-based model inhibits monopolization of the spectrum market, and, hence, cannot be recommended as an efficient approach among the service providers due to lack of control in terms of effective utilization of

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the allocated spectrum. In both the models, spectrum is assigned for a long period of time with static assignment; however, spectrum trading mitigates that in the market approach. Furthermore, in the administrator-controlled model, users have limited rights over the spectrum, while in the market-based model, there is inadequacy of transparent information of spectrum usage flow to regulators, and therefore making it less administrable.

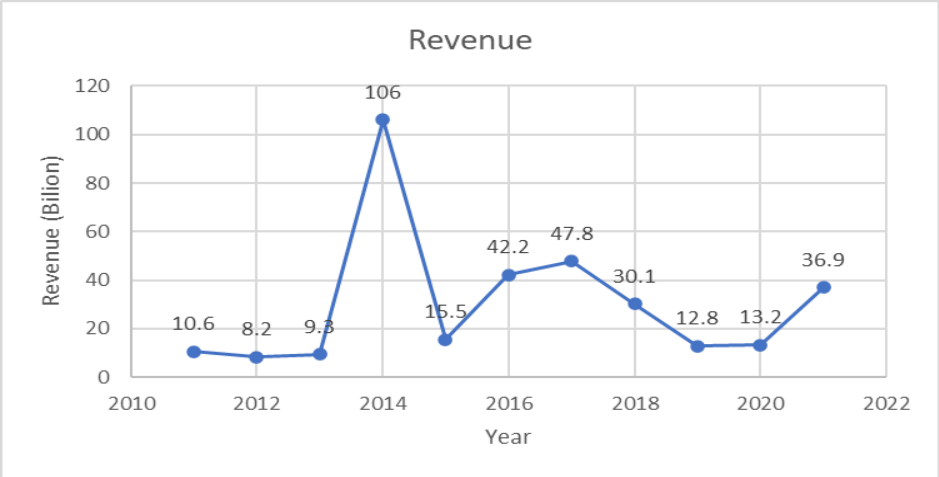

Figure 3. PTA Statistics of Revenue Generated within the Last Decade

Consequently, when there is not much to sell, in terms of spectrum allocation, in the market, there would be less revenue generated in return. Pakistan's National Regulatory Authorities (NRAs) are also facing the same issue — the problem to generate revenue by using spectrum efficiently and paving way for new market entities — for decades. Figure 3 depicts the decline in spectrum revenue generated after the auction of 3G and 4G licenses in Pakistan in 2014. A well-functioning spectrum market with a large number of frequencies available for allocation will be contingent for economic growth (Prasad, Sridhar & Bunel, 2016).

Therefore, policymakers must choose an appropriate administrative management policy, in future planning for effective deployment of 5G technology, that can be pivotal for minimizing interference issues and maximizing spectrum utilization, providing preferred economic incentives, and, thereby, introducing new opportunities for unlicensed uses. In addition, the administrative management policy must be able to productively confront the legal and political challenges that may arise from incumbent users and government regulations. Moreover, the management policy must profitably cater for dynamic assignment, easy access to all the classes, and be economically beneficial to the partner stakeholders (Hannabuss, 2006). In the authors' opinion, these factors will contribute enormously for more cognitive and dynamic spectrum access policies for the effective deployment and instalment of next generation wireless technologies.

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Dynamic Spectrum Access

To overcome the challenges offered due to spectrum scarcity and non-effective utilization of frequency bands, new communication techniques, i.e., Cognitive Radio (CR) and Dynamic Spectrum Access (DSA), were introduced. CR network provides efficient utilization of the limited radio spectrum with an added advantage of highly reliable communication to users through efficient energy and resource utilization (Nurelmadina *et al.*, 2021). On the other hand, DSA technique may allow unlicensed secondary systems to share the radio spectrum when not in use by licensed primary systems (Garhwal & Bhattacharya, 2012). However, this paper mainly focuses on the DSA technique and its impact on effective policy making for spectrum management.

From the core technical point of view, DSA capitalizes on the advantages offered with the utility of radio frequencies in an efficient manner where multiple users can access the radio band simultaneously. Moreover, DSA has the capability to share the radio frequency spectrum among multiple users or service providers at the same time without causing any interference among them and without degrading the quality of service. In relative terms, DSA is a set of techniques based on provisioning of frequency spectrum services with optimum use by the users. In addition, DSA defines a mechanism platform that allows accessibility of spectrum to multiple users. Furthermore, in the absence of primary users, the abundant white spaces in the radio spectrum can be accessed by secondary users to take technical and economic advantage of the capital resource (Song *et al.*, 2012). By converting the unutilized spectrum bands, economic advantages of dynamic spectrum access, as a flexible radio access policy that can replace the current fixed radio spectrum allocation policy without compromising the performance of the existing radio regulation governed by the conventional fixed spectrum allocation policy, can be achieved. Moreover, DSA, also referred to as Opportunistic Spectrum Access (OSA), specifies a new spectrum sharing paradigm that allows unlicensed or Secondary Users (SUs) to access the idle or unused spectrum, otherwise referred to as spectrum holes or white spaces in the licensed spectrum band (Singh *et al.*, 2020). Importantly, it is a flexible radio spectrum access policy to alleviate the current problems of spectrum scarcity and spectrum underutilization in order to increase spectrum utilization. The concept of DSA is to find a means of accessing the unused portion of already assigned licensed spectrum without interfering with the transmission of the Primary Users, as illustrated in Figure 4 (Popoola *et al.*, 2016). The type of radio that enables Secondary Users to operate in an idle portion of the licensed spectrum in this opportunistic manner works on the principal of cognitive radio.

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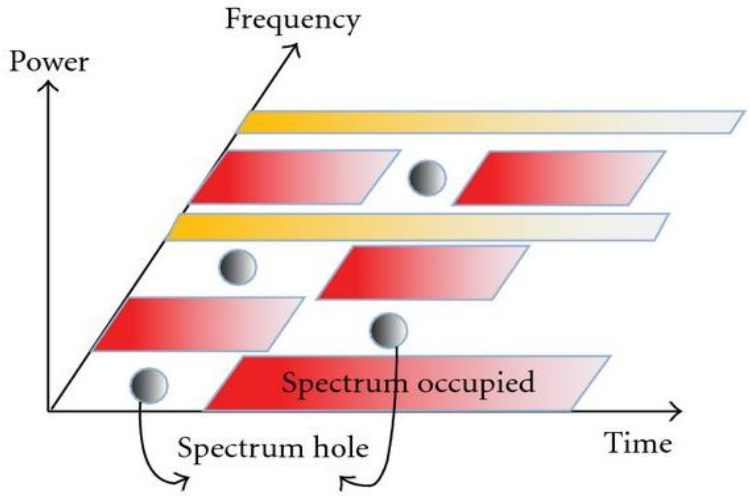

Figure 4. Spectrum Hole concept is showed and how these holes can be made usable through DSA (Popoola *et al.*, 2016)

CBRS

CBRS was initiated in 2012 by the FCC to enable spectrum sharing among multiple users; the rules were outlined in 2014 and officially adopted in 2015 (FCC, 2020b). Citizens Band Radio Services (CBRS), also known as Spectrum Access System (SAS), is a 150 MHz-wide band arranged on 3.5 GHz band (3550-3700 MHz). This is a valuable band that is chosen because of its ability to penetrate walls, go up to medium distances and transfer large amounts of data, which is a reasonable requirement of LTE and 5G.

The CBRS band is specially designed for spectrum sharing among tiers of different users: incumbent users; Priority Access Licensees; and Generally Authorized Access users. They all can use with conditions of priority to user plus no interference with each other. All tiers' detail is given (Kułacz *et al.*, 2019) with proper graphical representation in Figure 5.

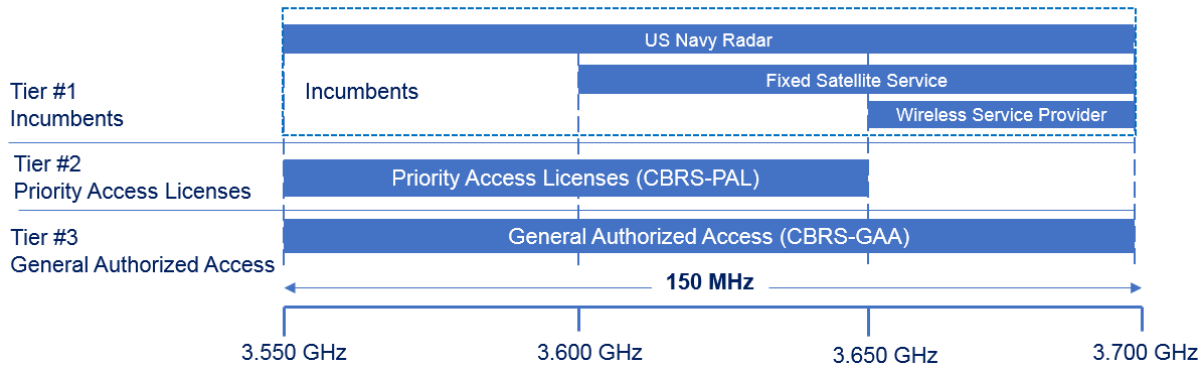

Figure 5. CBRS layer model provides information of three different users and their relevant uses (Kułacz *et al.*, 2019)

- Incumbents are old exclusive users of this band, such as satellite. An incumbent user shall not be interfered with by Priority Access Licenses and General Authorized Access users; its rights will be protected under rules defined by the authority. The existing

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band range defined formally for incumbents is 3650-3700 MHz. Priority is given to incumbent users over Priority Access Licenses and General Authorized Access users. Incumbents can acquire the license for a finite term.

- Priority Access Licenses belong to users who will pay for this license via auction. Through competitive auctions, the band of 3550-3650 MHz will be assigned to users with a maximum of 10 MHz on a single Priority Access License to a single applicant. A single applicant can take up to four bands of 10 MHz and can acquire the license for two consecutive terms. The PAL users shall not be interfered with by General Authorized Access users (GAA) as they will be prioritized over General Authorized Users.
- A GAA can use these bands when no-one from PAL or incumbent is using these bands. These users have freedom to use the 150 MHz (3550-3700) band, when it is not in use by incumbent or PAL users. In the presence of incumbent and PAL users, the band usage rights will be reverted from the General Authorized User. The priority of GAA is always less than PAL and incumbents.

CBRS/SAS is composed of multiple functions to become a complete system of spectrum sharing, as illustrated in Figure 6, where functional components are indicated for better understanding (Mueck *et al.*, 2020).

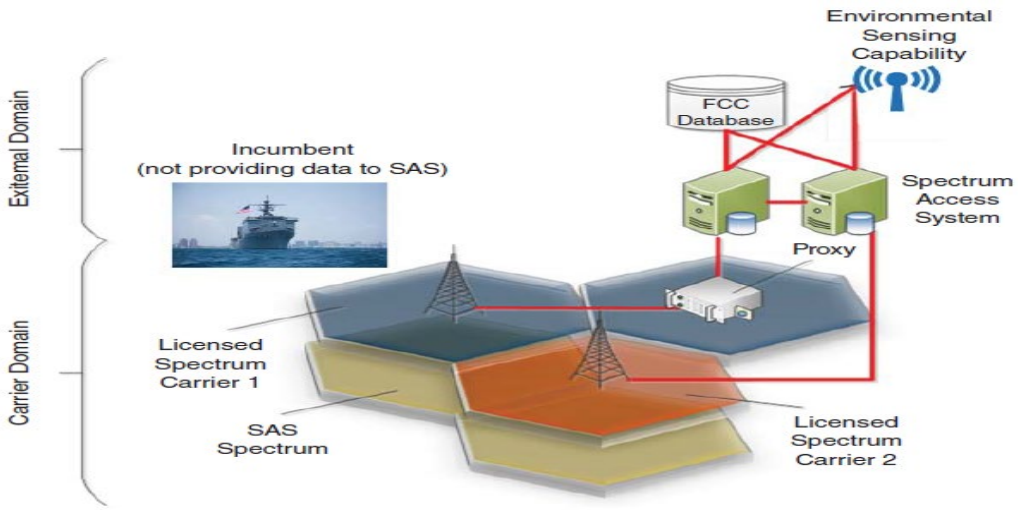

Figure 6. CBRS/SAS layer functional model (Mueck *et al.*, 2020)

- **Environment Sensing capability:** The environment sensing capability (ESC) senses the band operations by the incumbents and shares it with SAS to facilitate the protection of band operation and information in it. ESC works under the command and regulation set in the spectrum repository and sends alerts to SAS.
- **SAS Repository:** The FCC database, generally known as SAS repository, simultaneously collects the spectrum usage information from each node, including Citizen Band Service Device (CBSD) parameters, such as identification of spectrum, spectrum location,

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parameters of antenna, transmission power, and channel usage. The repository keeps updated with information for further channel allocations and interference management.

- **Domain Proxy**: An entity engaging in network management and aggregate communications with the SAS on behalf of multiple individual CBSD nodes or networks of such nodes. Those CBSDs, which are not directly controlled by SAS, get controlled and managed by a domain proxy on behalf of SAS under SAS-CBSD protocol. It intercuts the NMS function of other networks to configure CBSDs' frequency, bandwidth, transmit power, and operational state. NMS returns the collected CBSD information to Domain Proxy, which further sends it to SAS. Domain Proxy contains advanced functions for flexible self-control, interference reduction, and optimizing the coverage of cells (Swamy, Srinivasan &, Rashmi, 2020).

LSA

With the rise for new technology in the market, the need for spectrum sharing has also been highlighted in recent decades. In spectrum sharing, the frequency band that has been an exclusive property of an incumbent will be shared with other users for a specific time and location, when the band is underutilized or not efficiently utilized. The vacant spectrum will be utilized through Dynamic Spectrum Access methods, such as Licensed Shared Access (LSA), where vacant spectrum resources will be licensed or leased to users with proper guarantee of protection from harmful interference to incumbent users and vice versa. The incumbent's rights will be protected, plus they will be given a monetary share on leasing their underutilized spectrum. The development of LSA began in Europe for spectrum sharing between Mobile Network Operators (MNOs) for mobile broadband and an incumbent for its fixed conventional use, via proper agreement between both. The European Commission's Radio Spectrum Policy Group (RSPG) defines LSA as follows:

> "A regulatory approach aiming to facilitate the introduction of radio communication systems operated by a limited number of licensees under an individual licensing regime in a frequency band already assigned or expected to be assigned to one or more incumbent users. Under LSA framework, the additional users are allowed to use the spectrum (or part of spectrum) in accordance with sharing rules included in their rights of use of spectrum, thereby allowing all the authorized users, including incumbents, to provide a certain QoS" (Medeisis & Holland, 2014).

Also, Figure 7 shows the major stakeholders of LSA sharing framework, such as Incumbent, LSA licensee, and NRA.

- Incumbents are the old exclusive users in the 2.3-2.4 GHz band, who have the individual rights of use of the band.

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- LSA licensees, who have mutual sharing agreement with the incumbent to use the band; the protection against interference will be guaranteed for both the licensee and incumbent.
- NRA, which is responsible to supervise the agreed negotiation and sharing agreements between incumbent and Licensee. The licensing process and assurance to agreement from all stakeholders are also done by the NRA, under European Telecommunications Standards Institute (ETSI) and 3rd Generation Partnership Project (3GPP) specification.

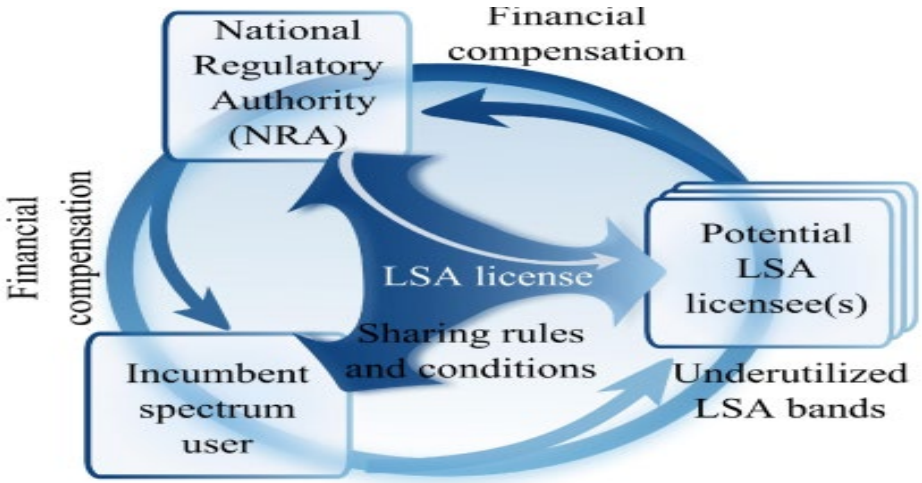

Figure 7. LSA Sharing framework between Tiers and Regulatory

LSA is composed of multiple functions to become a complete system for spectrum sharing, as illustrated in Figure 8, where functional components are described for better understanding (Mueck *et al.*, 2020).

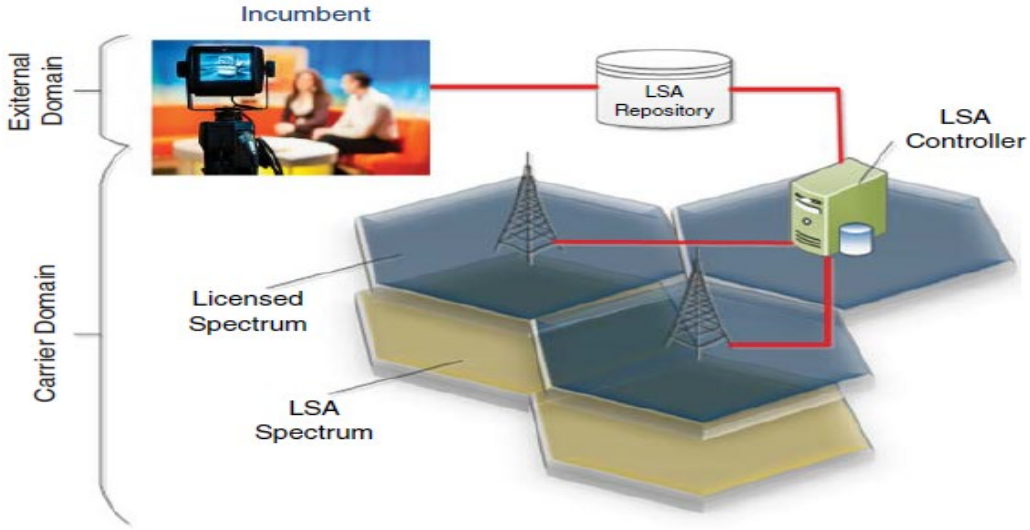

Figure 8. LSA Functional model

- **LSA repository:** LSA Repository will be the main spectrum database, that will contain proper spectrum data, policy, agreements on sharing, rules, and regulations. It will also monitor the users in real-time for interference avoidance.

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- **LSA controller**: LSA controller will manage the spectrum and LSA licensees under the information retrieved from the LSA repository; it will allocate and shut down the channel transmission as directed by the LSA repository.
- **Incumbent:** Incumbent will continuously inform the LSA licensee about the vacant spectrum and its availability.

The International Telecommunication Union (ITU-R) has globally allocated the band range of 2.3-2.4 GHz to mobile broadband services and International Mobile Telecommunication (IMT) (Moghaddam, 2018). The European Commission started to develop standards for the launch of LSA in Europe on 2.3-2.4 GHz band. In Europe, within this band range of 2.3-2.4 GHz, countries and regulators are using the band for PMSE (Program Making and Special Events), such as cordless cameras and video links, while some others are using it for fixed satellite, government use including military, and mobile applications, such that it would not require additional features in infrastructure with implementation of LSA. As compared to Europe, it would be difficult for North America to vacate this band from incumbent usage and protection (Yrjölä, Ahokangas & Matinmikko, 2015).

LSA framework does not provide subleasing opportunities to additional frequency bands. The next stage of LSA framework is evolved Licensed Shared Access (eLSA), which enables spectrum access to local high quality or Vertical Sector Players' (VSP) wireless networks under NRA decision. Additional resources will be leased/subleased to local wireless operators. These local operators will be dealt with directly by the NRA under standard agreements and sharing agreements, which will define an allowance zone and frequency range, keeping interference low and QoS high (ETSI, 2020).

CBRS vs LSA model

The concept of CBRS is deployed in America, while Europe has foreseen LSA for commercial deployment in order to achieve spectrum sharing (Massaro & Beltrán, 2020). Although both have multiple layer similarities, such as that both models are comprised of incumbent users and licensed users, however, they are not completely similar. Table 2 illustrates the comparative analysis of CBRS vs LSA. In LSA, shared access users are known as Licensed Shared Access Licensees, whereas in CBRS they are known as Priority Access Licensed users. LSA does not provide opportunistic access to general users, but CBRS/SAS came up with an additional third tier known as General Authorized Access to give spectrum band access to unlicensed users in the absence of incumbent and PAL users, so the PAL user is protected from GAA interference and incumbents are protected from both PAL and GAA users (Yrjölä & Kokkinen, 2017). We can say SAS gives priority to incumbents and they are not required to share prior spectrum usage information due to secrecy with central data. Therefore, SAS uses

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Environment Sensing Capability (ESC) to sense spectrum usage and sends the information to the central database for decision making, but the LSA repository takes spectrum utilization information from incumbents as well (Moghaddam, 2018). The mentioned frequency band for LSA is 2.3-2.4 GHz, while CBRS is being deployed on 3.55-3.70 GHz.

Table 2. Comparative Analysis of CBRS and LSA

Aspects	LSA	SAS/CBRS
Released by	Released by ETSI	Released by FCC
Tiers	Two tiers with individual Access	Three tiers; two tiers for individual access and one for general opportunistic access
3GPP Band	LTE TDD Band 40 (2.3-2.4 GHz) applicable for other countries (The Global Solution for Unpaired Spectrum, 2014)	LTE TDD Band 42 and 43 (3.55 GHz - 3.7 GHz) applicable for other countries (The Global Solution for Unpaired Spectrum, 2014)
Database	Centralized Geolocation database on static a priori information of the incumbents (Kalliovaara, Jokela & Kokkinen, 2018)	Centralized Geolocation database based on spectrum sensing (Kalliovaara, Jokela & Kokkinen, 2018)
Spectral Efficiency	Less efficient with individual access	More efficient with individual and General access
Complexity	Less complex with a static framework for long term	Much more complex due to sensing and of GAA users
Adaptability	Initiated from Europe but easily can be adapted by other regions (Massaro & Beltrán, 2020)	Initiated by USA, but can be adapted to other regions (Massaro & Beltrán, 2020)
Revenue Expectations	With more users, there will be more expected revenue	With more users, there will be more expected revenue
Extensions	CBRS is a potential LSA extension with three tiers with individual and general tiers	Already have three tiers with individual and general access
Incumbent Access	No direct access for SAS to Incumbent; ESC just detects incumbent usage information (Kułacz *et al.*, 2019)	LSA have partial access to incumbent information for usage sharing, agreement and usage information
Interoperability	Defined enabling standardized interoperability	General level requirements and frameworks furthered with agreements
Sub licensing	Sublicensing supported to PAL users	Sublicensing is not supported in LSA; however, eLSA will support (ETSI, 2020)
QoS Assurance	Through a standardized framework, QoS is assured for incumbent and PAL access but GAA users are not guaranteed with QoS (Parvini *et al.*, 2022)	QoS is assured to incumbent and licensees through LSA framework and sharing work (Parvini *et al.*, 2022)
New users	Does not allow new users to be in framework	CBRS provides advantage to new inexperienced MNOs
Practical Deployment	Scarce interest of European countries towards deployment (Massaro & Beltrán, 2020)	Already deployed by FCC in United States (FCC, 2020a)

ETSI has already standardized LSA for Europe, while CBRS is being standardized by Federal Communication Commission (FCC) for America. Licensing will be initiated soon in these

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regions and they will become the model example for the rest of the world. The CBRS-based approach appears to be more acceptable, with an innovative initiative of serving individual and general users. However, opportunistic general access is not a priority, though QoS could be envisioned for individual users, such as PALs, as LSA seems to be moving itself to evolved Licensed Shared Access (eLSA). The eLSA is almost giving the same concepts as CBRS, with the addition of a local vertical sector (local wireless networks) beside the main licensed users and incumbent (Moghaddam, 2018). CBRS is facilitating a diverse range of wireless ISPs, enterprises and, moreover, rural ISPs. Opportunistic access to rural areas for ISPs will likely improve the capacity and quality of networks (Calabrese, 2021).

Comparative analysis provides more edge to Citizens Band Radio Service, as it provides more flexibility and is a better model to be deployed in Pakistan as the national framework for spectrum sharing. It provides more tiers and user options to serve national cellular mobile operators, incumbents and general users. With the launch of 5G, regulators will be under great pressure to provide radio bands to all users in a balanced manner. Therefore, the need for dynamically accessible spectrum and sharing frameworks would indeed be a great opportunity to facilitate radio spectrum services to existing as well as new market users.

Conclusion

The traditional spectrum assignment frameworks, such as CCA and MBA, have been in use from a long time, but their efficacy has become low with the passage of time and the rise of innovative technology, especially cellular mobile technology. As a resultant, the traditional framework has failed to provide reasonable economic and technological advantage. Like other countries of the world, Pakistan is also facing the issue of non-availability of enough spectrum for meeting technological and economic requirements of the nation. The NRA has not yet decided on which framework or policy it is going to deploy for spectrum management in Pakistan. DSA suggests the innovative way to utilize spectrum and improve its technical and economic advantage with more users and vacant space in the spectrum domain.

In this research work, Europe-based LSA with two tiers and US-based CBRS with three tiers were briefly compared with each other on multiple aspects, to sort out a better framework to be deployed in Pakistan. Both approaches provide a clear solution for dynamic frequency allocation and will provide a solid platform for the launch of 5G services. However, these approaches may be used as complimentary solutions for operators having ownership of bands through traditional methods, keeping in mind that CBRS provides more flexibility to the users and a management framework to operate and entertain every tier, including incumbent, priority licensed and non-licensed general access users. With a more flexible architecture for all-purpose users, CBRS proved to be a better option to be adapted by Pakistan for cellular

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mobile network operators. There is no restriction to deploying the CBRS band in Pakistan, as this band is already under refarming for future allocations. Hence, CBRS will not only utilize the scarce resource efficiently but also paves the way for inclusion of new technologies in the upcoming future.

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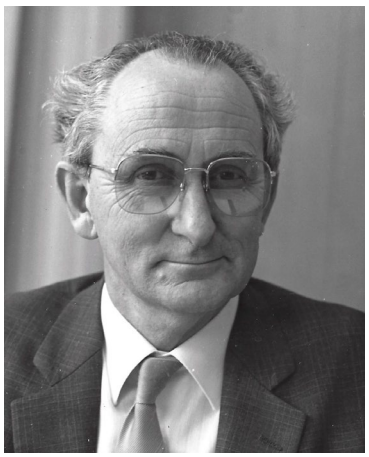
John Nils Almgren (1930–2021)

An Outstanding Figure in Australian Telecommunications Manufacturing, and in Philanthropy



Peter Gerrand
University of Melbourne

Abstract: John Nils Almgren AM (20 June 1930 to 24 December 2021) was renowned in the Australian telecommunications industry for his success, together with his wife Yvonne, in building a major Australian manufacturing company, J. N. Almgren Pty Ltd, starting from scratch in 1960. JNA began as a custom-designer of small electromechanical subsystems for the PMG and State electricity utilities, but later developed successful electronic products for public and private data networks for large corporations. The company was floated on the ASX in 1992 as JNA Telecommunications Ltd. It operated internationally until bought by the US company Lucent Technologies in 1998. John and Yvonne became significant philanthropists, often declining any publicity for their generous donations.

Keywords: Australian telecommunications, History of Australian telecommunications, J. N. Almgren, JNA Telecommunications, Charles Todd Medal

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Early Life and Education

John Nils Almgren was born in Woollahra, NSW on 20 June 1930, to a Swedish father and an English mother. His father, Gustav Harald Almgren, born in Sundsvall, Sweden, arrived in Australia in 1918. His mother, Phyllis Muriel Panter, met Gustav in Sydney in the 1920s. Tragically, Gustav died at age 45, when John was only five.

John attended local primary schools and then North Sydney Boys High School until 1945, when he left, aged 15, with an Intermediate Certificate. He had gained high marks, but family circumstances did not permit him to continue his schooling. His first job after leaving school was working at a bakery.

In 1946, John joined the electronics company Communications Engineering Pty Ltd, later renamed T. S. Skillman Pty Ltd, as a junior. Over fourteen years, he worked his way up to becoming appointed as a design engineer and "all-round trouble shooter". His skills led to him being sent to Hawaii by Skillman on more than one occasion to solve problems with equipment they had supplied there (Williams, 2022).

John's colleague and friend Graeme Williams writes:

> "This where the JNA story began. Having worked wholeheartedly for his employer, it came as a bit of shock to John when the company went broke (in 1960) and John became unemployed.
>
> "John that day made a promise to himself that he would never work for anyone else, and that his future success or otherwise would be as a direct result of his own actions, not those of others.
>
> "John, with his young wife Yvonne, whom he [had] married in 1953, started their own business employing some close family members and friends, five persons in all. Both John and Yvonne worked tirelessly in the business and there was a real family production line established" (Williams, 2022).

The company was named simply J. N. Almgren Pty Ltd, soon known across the industry as JNA.

The Growth of JNA

In 1986, John Almgren wrote of his company's early history:

> "When our company was formed in 1960, our aim was to provide our customers with a specialised service. This effectively boiled down to providing a 'design and build' answer to the customer's problem of getting replacement equipment, usually in very small quantities,

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to get telecommunications systems fully operational again. The customer's needs were often precise, unique and technically demanding.

"We had to be flexible in our planning to accommodate short term demands which cropped up without much notice. Designs had to be aimed at providing a first-class solution, whilst using only components and materials which were readily available.

"As our financial resources were very small, it was essential to make every pound (or dollar) count. In those days banks were not prepared to be entrepreneurial. Slowly, very slowly but surely, we were able to consolidate and develop" (Almgren, 1986).

Allan Horsley was a customer of J. N. Almgren during his time with Plessey in the 1960s and later with the State Electricity Commission of Victoria in the 1970s.He writes:

"John had a reputation as a high-quality manufacturer who delivered on time. John's business was very skilled in the manufacture of custom-designed electromechanical and electronic devices. For example, it made 'barrier relays' to enable PMG services to be connected into high voltage electrical locations, able to withstand 1,000 volts or more. It made small volume devices for both the telecoms sector and the electrical power sector.

"JNA fitted in at the volume levels below the 'big end of town' system suppliers, such as TEI, STC and Ericsson."

Accommodation and Financial Challenges

The practical challenges John and Yvonne faced in establishing their company were considerable (Almgren, 1986):

"Our first 'factory' was in a one-time bakehouse in Mosman. We had about one hundred and fifty square feet [14 m²] of space, which was reasonably OK until the rains started. A leaky roof, made considerably (and intolerably) worse by two tradesmen in big boots clumping about to give a roof repairs quote, convinced us that we should move.

"We then moved to North Sydney, where we occupied the basement of a residential building. The local Council classified us as a 'service industry', because we were using less than 1,000 square feet [93 m²]. (We had about 300 square feet [28 m²] of workroom space.) I remember the Council's Form referred to a Service Industry as one which, for example, repaired pushbikes or umbrellas. Not really high technology by any stretch of the imagination.

"As time progressed, we found ourselves once again looking for some more space. This time we found about 1,200 square feet [111 m²] in Willoughby — a first-floor location, previously occupied by The Willoughby Pastime Club — which was the local S.P. Bookie!

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> "After cleaning the place up, adding extra amenities, removing the black sheeting from the windows, cutting through a strange array of very unofficial and unauthorised internal telephone wires, and washing the office partition glass to get rid of the skin of nicotine, we moved in.
>
> "We also had to repair the front door, which was damaged when the establishment was raided by the local gendarmes.
>
> "Over the next few months, from time to time, various quiet little men would appear on our doorstep and enquire if it was possible to 'get a bet on'. It didn't take long for them to realise that things had changed — at which time they seemed to de-materialise in an instant.
>
> "In 1977/78 we started looking for bigger, better premises. This time we wanted to get something of our own. (Some of the banking people thought we were being presumptuous but we didn't agree.) After a lot of effort we were able to buy the land at 16 Smith Street and have our factory built. On site work started late '78 and we moved in late May, 1979. The 7,500 square feet [700 m^2] and parking would certainly last us for eight or ten years." (Almgren, 1986)

Business Development

Graeme Williams continues: "A fair chunk of JNA's early business was with the PMG Department (later Telecom Australia); and that indeed was where John first ran across a bright young engineer named Peter Davies, who would ultimately become John's long-term business partner and confidant" (Williams, 2022). Together, they grew the business into its pre-eminent position in the Australian telecommunications manufacturing industry.

In the 1970s, most of JNA's business lay in the design and supply of analogue equipment, with digital products accounting for only 5 to 10%. However, an opportunity arose in 1975 – when their prime customer, the PMG, had morphed into Telecom Australia – to design and supply some digital interface units. To cope with this requirement, they increased their engineering staff from three to five.

John Almgren (1986) continues:

> "In the early 1970s we were able to tender successfully to the Maritime Services Board of NSW for the design and manufacture of speech and signalling equipment. The initial value of this job, comprising more than 20 racks of equipment, was about $70,000 — our biggest job to date.
>
> "At about the same time, we decided to enter the 'Standard Products' arena. Prior to this, we had effectively only produced equipment against customers' orders. Now we were

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> prepared, at our commercial risk, to design, develop and build selected types of data communications 'building blocks' (or "black boxes") which we would offer to the marketplace.
>
> "Many things were changing. Now we were involved not only with hardware, but also with software."

Managing the new digital technologies meant hiring more technical staff and more equipment for developing hardware and software. But Almgren and Davies were canny on managing their financial growth:

> "The implementation of our internally managed JNA No.1 Superannuation Fund was an essential step in our progress. In mid-1977, we started this Fund with several objectives in mind, i.e.,
>
> - the long-term benefit of employees;
> - the acquisition of our own premises; and
> - the development of our professional capability by the acquisition of more plant and stock.
>
> "We were able, by controlled 'loan-back' to achieve these goals" (Almgren, 1986).

In his 1986 memoir, John expounded on his management philosophy:

> "For all of the quarter of a century that we have been in business and, indeed, for our future, we have placed and will continue to place, highest emphasis on our operating as a first-rate team in which EVERYONE is important.
>
> "We look to the future which will provide us with much interesting and exciting challenge. As a very skilled team we have a lot to offer, both to the Australian and overseas markets. We are capable of providing products and services second to none.
>
> "Our aim is that we are all able to achieve our goals with a lifestyle both satisfying and dignified" (Almgren, 1986).

By the mid-1980s, JNA had built major private data networks for Australia's top four banks (ANZ, CBA, NAB and Westpac) as well as essential systems and components of Telecom Australia's first public packet switched network, Austpac, and multiplexers and matrix switches for Telecom's Digital Data Services network. JNA also identified the need by business users, both medium and large, for network management via Individual Circuit Monitoring systems, which JNA designed, built and installed.

By 1986 JNA had also installed packet switched networks for Australia's largest oil company, Esso, and largest mining company, BHP, and EFTPOS networks for some of the major banks.

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To achieve this, by 1986 JNA's staff had grown to 126, consisting of seven in senior management, 38 in engineering. 18 in customer services, 20 in sales and marketing, 25 in manufacturing and 18 in administration (Almgren, 1986).

Floating the Company in 1992

To achieve the financial resources that would enable the company to expand into overseas markets, John transformed his private company in 1992 into JNA Telecommunications Ltd, which successfully floated on the Australian Stock Exchange in 1992. John remained Chairman and Peter Davies was Chief Executive Officer.

As a further indicator of John's character and reputation, he was able to recruit onto the Board of JNA Telecommunications the former Managing Directors of Telecom Australia (Mel Ward AO) and of the Commonwealth Bank (Len Spencer).

Expanding its sales into the Asia-Pacific (most notably to China, Thailand and Vietnam), the Middle East (Egypt and Syria) and South America, the company achieved peak revenue of $73.6 million in 1995. In 1997, it expended $9.1 million on research & development; and earned export revenues of $14.6 million. Meanwhile, its Australian customer base remained strong, including Australia Post, Australian Customs, Woolworths, QBE Insurance, Metway Bank, SA Tab, CSIRO and the Department of Defence, in addition to its traditional customers Telstra and the larger banks. At the time of JNA's sale to Lucent, JNA's R&D team alone amounted to more than eighty staff (Budde, 1998).

Lucent Technologies bought JNA Telecommunications in July 1998 for $114 million. The purchase was a testimony to JNA's engineering expertise, sales channels, industry reputation, intellectual property and financial record.

Leadership in Industry

Former Managing Director of the industry business lobby group ATUG (the Australian Telecommunications Industry Group), Allan Horsley, writes of John Almgren that: "He was revered in the industry as somewhat of a doyen, a successful Australian manufacturer, of which there were few".

At different times in his career, John took on the positions of a Board member and later President of the Australian Electrical & Electronic Manufacturers Association. He was also an active member of the Australian Electronics Industry Association and the Australian Telecommunications Industry Association. At one time, he was Chairman of the NSW Government's Schools' Visit to Industry program ('New Fellows', 1996).

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John was a key member of the Advisory Committee to the Australian Electronic Development Corporation (AEDC), from 1989 to 1992, when Trevor Barr (now an Emeritus Professor) was its Director. The AEDC was set up in 1989 with five years' sponsorship from the Federal Government, Ericsson Australia, Siemens, NEC, Hewlett Packard, IBM and Telstra. Its purpose was to provide training courses and shared infrastructure services to the staff of small and medium electronic design companies in Australia, to make them internationally competitive.

Trevor Barr mentions that John, whose own company had already achieved what the AEDC was trying to provide to its client companies, was always full of valuable ideas in the Advisory Committee. He recalls John's mantra: "offer short, practical advisory capsules" in areas of need. "He was always popular with Centre staff, ready to help anyone. John was a first-rate human being."

Figure 1. John Almgren, on left, being awarded his certificate as a Fellow of the Telecommunications Society of Australia by its then Chairman, Professor Peter Gerrand ('New Fellows', 1996)

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John's extensive contributions to the telecommunications industry were recognised in his being awarded the prestigious Charles Todd Medal by the Australian Telecommunications Users Group in 1994, Membership in the General Division of the Order of Australia (AM) by the Australian Government in 1995, and a Fellow of the Telecommunication Society of Australia in 1996.

Philanthropy

> "John's integrity, generosity, humility and sincerity have always been on display throughout his working life. The staff at JNA would receive gifts of appreciation from John on a regular basis, especially at Easter and Christmas. John was always up for a chat and was a beloved father figure to the staff at JNA.
>
> "I have had people relay to me that, beyond their parents, John had the greatest impact on their lives. He was an exceptional person – a gentleman and a friend – and he touched the lives of so many people. Such was the stature of the man" (Williams, 2022).

After the sale of JNA in 1998 to Lucent, John and Yvonne were able to greatly increase their philanthropy. They made generous donations to the former Port Stevens Branch of the Royal Volunteer Coastal Patrol (now the Marine Rescue), the Australian Flying Doctor Service, Care Flight, Dunmore Lang College, the Sir David Martin Foundation, and the Australian Brandenburg Orchestra. In the case of the Royal Volunteer Coastal Patrol, John and Yvonne provided cheques for not only a new rescue vessel in 1999, but also for "two members of the Coastal Patrol to fly to England to inspect and test the vessel for sale, and to cover any spare parts needed for the vessel if they purchased it" (Reeson, 2022).

Within the telecommunications industry, John Almgren sponsored two of the annual Charles Todd Orations in Sydney, hosted by TelSoc's predecessor, the Telecommunication Society of Australia (TSA), in the early 2000s.

After the TSA re-established itself as the Telecommunications Association Inc. (TelSoc) in 2007, John Almgren made generous donations over four years to keep the new society financially afloat, but he insisted that his donations be kept anonymous. He was a popular figure at the annual Charles Todd Oration lunches in Sydney.

The Australian telecommunications industry owes John Almgren a lot.

Conclusion

John Almgren was as renowned as much for his character – his integrity, generosity, humility and sincerity – as for his major achievements as a business entrepreneur. Together with his wife Yvonne, he built a major Australian manufacturing company, J. N. Almgren Pty Ltd, from

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scratch in 1960 to become the publicly listed JNA Telecommunications (1992–98), eventually bought out and absorbed by the giant US company Lucent Technologies in 1998. In retirement, John and Yvonne became significant philanthropists. John's role as an anonymous donor to the newly created Telecommunications Association Inc. (TelSoc) from 2013 to 2017 was crucial to its survival and growth.

Acknowledgements

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Regional Mobile Telecommunications Access, Competition and Public Benefits

Mark A Gregory
RMIT University

Abstract: The Australian Competition and Consumer Commission (ACCC) received an application for merger approval from Telstra Corporation Limited and TPG Telecom Limited related to three interrelated agreements that would put in place a Multi-Operator Core Network (MOCN) arrangement. The three agreements include a MOCN Service Agreement, a Spectrum Authorisation Agreement, and a Mobile Site Transition Agreement. This paper considers the proposed arrangements, identifies that the ACCC's failure to declare domestic mobile roaming in 2018 was, in some large part, responsible for the market environment that fostered the current proposal, and that the proposed arrangements are not a satisfactory mechanism to fundamentally improve the delivery of reasonably priced, open and competitive, reliable, and high-quality mobile telecommunications in regional and remote areas.

Keywords: Mobile, Telecommunications, Australia, Telstra, ACCC

Introduction

Telstra Corporation Limited (Telstra) and TPG Telecom Limited (TPG) lodged a merger application with the Australian Competition and Consumer Commission (ACCC) on 23 May 2022 (ACCC, 2022).

The application for merger authorisation covers three interrelated agreements related to a Multi-Operator Core Network (MOCN) commercial arrangement. The arrangement includes a MOCN Service Agreement, a Spectrum Authorisation Agreement and a Mobile Site Transition Agreement.

Under existing rules, the ACCC is required to publish a decision on the merger application within 90 days of the lodgement date. An extension can be requested by the ACCC. The applicants have agreed to an extension request from the ACCC. The ACCC now has until 17 October 2022 to decide on the application.

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The ACCC has invited submissions on the MOCN commercial arrangement. The submissions are to be considered in the authorisation process.

The Applicants seek to establish an arrangement for Telstra to use spectrum currently held by TPG, Telstra providing TPG with network services in selected regional and urban fringe areas (the Regional Coverage Zone), and for TPG to transfer ownership of up to 169 existing mobile sites in the Regional Coverage Zone to Telstra. TPG will use the MOCN commercial arrangement to offer 4G and 5G retail and wholesale services and to decommission mobile sites no longer required in the Regional Coverage Zone. The MOCN service agreement would have an initial term of 10 years, with an option for TPG to extend the agreement twice with five-year extensions.

This paper considers the proposed MOCN commercial arrangement between Telstra and TPG (the Applicants).

Background

The Australian mobile telecommunications market has evolved since telecommunications deregulation commenced in 1997. Today, there are three dominant carriers in the Australian mobile telecommunications market: Telstra, Optus and TPG. In addition, there are a number of smaller operators and Mobile Virtual Network Operators (MVNO).

Regional mobile telecommunications is dominated by Telstra due to its history and generous local, State and Commonwealth government grants over the past decades that have provided assistance to Telstra to build out its regional telecommunications network.

In 2014, after consultation with the telecommunications industry, the federal government introduced a Mobile Black Spot Programme (DITRDC, 2022) to provide mobile network operators and network infrastructure providers with co-funding for new infrastructure in selected areas. To date, this program has generated a total investment of more than $875 million delivering more than 1,270 new mobile base stations across Australia.

Most of the Mobile Blackspot Programme funding has been allocated to Telstra due to its position in the market and other factors, including the fact that it is the only network provider in large areas of regional and remote Australia and, in many locations, the only carrier with access to regional backhaul capacity.

In an earlier paper (Gregory, 2021), regional mobile telecommunications was discussed with a focus on performance and, in particular, throughput (capacity). The paper also provides a background discussion on issues affecting regional mobile telecommunications. One important issue was the ACCC's decision to not declare domestic mobile roaming in 2018 after a public inquiry was completed.

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Domestic mobile roaming declaration

The MOCN service agreement between Telstra and TPG is a logical and pragmatic outcome of the flawed decision by the ACCC to not declare domestic mobile roaming in 2018. The failure of the ACCC (Gregory, 2021) to acknowledge and understand that new competitive infrastructure would not eventuate in large areas of regional and remote Australia underpins the rationale for TPG to seek to put in place a service arrangement with Telstra.

In the years after the ACCC's domestic mobile roaming inquiry, the disparity between the Telstra regional mobile telecommunications network and the competitor networks appears to have increased (Telstra, 2021a), and Telstra has attracted most of the Mobile Black Spot funding from the Commonwealth and State governments (Telstra, 2021b). Consequently, there does not appear to have been a substantive change in the area of regional Australia that is covered by more than one mobile network operator.

Regional mobile telecommunications performance

A global shift away from providing physical access to services by governments and businesses means that regional mobile telecommunications has become an essential service that fundamentally affects access to services and, consequently, the quality of life and economic outcomes. There are three fundamental and measurable parameters that, when combined, provide the basis upon which judgements about mobile telecommunications can be made. The parameters are cost, access and performance.

The proposed MOCN service agreement between Telstra and TPG principally affects access and to a lesser extent cost. The information made available does not appear to provide guidance on minimum mobile telecommunications performance levels for either carrier in the Regional Coverage Zone.

Competition

The proposed MOCN service agreement between the largest (Telstra) and third largest (TPG) mobile network operators excludes the second largest (Optus) mobile network operator. This is not a balanced, open and competitive outcome; however, this is offset by the public benefit of TPG gaining an increased presence in the Regional Coverage Zone.

There is a question over the financial competitiveness of the proposed MOCN arrangement. As the financial details are not available, it is therefore reasonable to assume that the arrangement would benefit Telstra more than it benefits TPG. Optus would not benefit and may find an overall negative impact on its national competitiveness.

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It is also important to note that this arrangement affects the MVNOs that utilise the Optus mobile network and, as discussed later, is likely to have a detrimental effect on regional small network operators.

In this instance, the question of competition is considered in three parts: infrastructure, spectrum and services.

Infrastructure

The MOCN service agreement increases the size of the Telstra mobile network when compared with the other operators. Telstra's dominance in the transit network market further reduces the likelihood of infrastructure competition in regional and remote areas. It is reasonable to assume that, if the MOCN service agreement commences, then further infrastructure investment by TPG will not occur in the Regional Coverage Zone whilst the agreement is in place. This outcome would further undermine the rationale behind the ACCC's flawed decision to not declare domestic mobile roaming in 2018.

The question becomes: if TPG stops investing in infrastructure in the Regional Coverage Zone whilst the agreement is in place, does this reduce competition?

Infrastructure competition is not a fundamental component of market competition, particularly when the infrastructure can be shared without mobile telecommunications performance loss or when sharing is a price-regulated requirement.

In 2021, Telstra "completed the sale of a 49 per cent non-controlling stake in its towers business for $2.8 billion" (Telstra, 2021c). Also in 2021, Optus announced the sale of a 70 per cent "stake in Australia Tower Network (ATN), a wholly-owned subsidiary which operates Optus' passive telecommunications tower infrastructure, to AustralianSuper" (Optus, 2021).

The mobile telecommunications market spectrum auctions ensure that the carriers hold different spectrum lots and generally this means that all carriers can utilise shared infrastructure, including shared access to a common Radio Access Network (RAN), which can avoid unnecessary equipment duplication on towers.

Spectrum

The Applicants' submission to the ACCC seeks merger authorisation that effectively permits Telstra to use TPG's spectrum holding and this is deemed by Section 68A of the *Radiocommunications Act 1992* (Commonwealth) to be an acquisition as identified in Section 50 of the *Competition and Consumer Act 2010* (Commonwealth).

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The Applicants have submitted that the Spectrum Authorisation Agreement, MOCN Service Agreement and Mobile Site Transition Agreement are commercially and legally interdependent and should be considered as a whole.

Competition in the Australian mobile telecommunications market is predicated on the understanding of how spectrum lots are allocated, auctioned and utilised by the successful bidder.

Spectrum is first and foremost an economic renewable resource that is allocated according to the government's social and economic policy. The government utilises a legislative instrument to direct the Australian Communications and Media Authority (ACMA) to auction spectrum in lots with spectrum licence limits. Spectrum may be set aside for one or more carriers to purchase or be auctioned with allocation limits. The purpose of this process is to ensure that the carriers have spectrum holdings that will facilitate competition in the mobile telecommunications market.

The proposed Spectrum Authorisation Agreement, if approved, would provide a mechanism for carriers to share or swap spectrum in one or more areas where they operate a mobile network or in fact do not operate a mobile network, as is the case here.

Another potential outcome could be carriers reducing the price bid for spectrum at auction because they have a pre-existing spectrum sharing arrangement or have had discussions on a future spectrum sharing arrangement. This outcome could be detrimental to the government's maintenance of spectrum as a renewable revenue source.

The proposed Spectrum Authorisation Agreement appears to be at odds with the legislative instruments (AusGov 2012; AusGov, 2018; AusGov, 2021) issued to the ACMA that set limits on carriers bidding for spectrum at auction and utilising the spectrum subsequently.

The *Radiocommunications (Spectrum Licence Limits) Direction No. 1 of 2012* (AusGov, 2012), paragraph 4, states:

> (1) I direct that the ACMA must determine procedures under subsection 60(1) of the Act that impose limits that ensure that, as a result of the allocation of spectrum licences under Subdivision B of Division 1 of Part 3.2 of the Act, no person or specified group of persons may use more than:
>
> (a) 20MHz of spectrum available in the designated area in the frequency band 703MHz to 748MHz; and
>
> (b) 20MHz of spectrum available in the designated area in the frequency band 758MHz to 803MHz.

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The *Radiocommunications (Spectrum Licence Limits—3.6 GHz Band) Direction 2018* (AusGov, 2018), paragraph 5, states:

> (2) The limits imposed must:
>
> (c) ensure that no person or specified group of persons may, as a result of the allocation of a spectrum licence that is enabled by a relevant re-allocation declaration, use:
>
> (i) more than an aggregate of 60 MHz of the relevant band in each metropolitan area (whether or not at the same location in that metropolitan area);
>
> (ii) more than an aggregate of 80 MHz of the relevant band in each regional area (whether or not at the same location in that regional area)[.]

The *Radiocommunications (Spectrum Licence Limits—850/900 MHz Band) Direction 2021* (AusGov, 2021), paragraph 5, states:

> (1) I direct the ACMA to determine allocation procedures under subsection 60(1) of the Act that impose limits, in accordance with sections 6 and 7, on the aggregate of the parts of the spectrum that may, as a result of the allocation of spectrum licences under Subdivision B of Division 1 of Part 3.2 of the Act, be used by any one person or by the groups of persons specified in those sections.
>
> (2) The limits imposed must apply to the allocation of spectrum licences in the 850/900 MHz band enabled by the re-allocation declaration.

Paragraph 7 states:

> 7 Limit applying to all persons and relevant groups of persons
>
> (1) For this section:
>
> (a) the limits imposed must apply in relation to the sub-1 GHz band in the major population area and the regional area; and
>
> (b) the limits imposed must ensure that no person or relevant group of persons may use:
>
> (i) more than an aggregate of 82 MHz of the sub-1 GHz band under spectrum licences in the major population area; or
>
> (ii) more than an aggregate of 92 MHz of the sub-1 GHz band under spectrum licences in the regional area[.]

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The legislative instruments clearly state that "no person or relevant group of persons may use" and this appears to indicate that the Spectrum Authorisation Agreement cannot be authorised by the ACCC, unless there is another interpretation of the Act or of the legislative instruments being relied upon.

The Applicants state (TelstraTPG, 2022) in paragraph 139 that: "Telstra does not need to make 5G available to TPG at a particular site in the 17% Regional Coverage Zone until six months after the site was activated for 5G for Telstra Comparison Customers (subject to some limited exceptions)". This statement indicates that, for a period of six months at each site in the Regional Coverage Zone, Telstra can enjoy a period when it is fully utilising the pooled spectrum. This statement highlights the need for clarity on whether or not the ACCC is in a position to override the legislative instruments or there is some other legislation or interpretation upon which the ACCC could support this arrangement.

The Applicants further state (TelstraTPG, 2022) in paragraph 241 (a): "the relative proportion of use [of the pooled spectrum] between Telstra and TPG will be determined by their competitiveness at the retail and wholesale levels. It cannot be assumed that one or the other would get more or less as this is a process of competition …". An open, fair and competitive telecommunications market does not commence with one network operator having all of the infrastructure and all of the customers in an area, unless there are actions taken through legislation and regulation to balance the "playing field". In this instance, Telstra and TPG appear to be asking the ACCC to take a leap of faith that the MOCN arrangements will put in place an open and competitive environment for Telstra and TPG to grow market share. What-ifs should not be part of the ACCC's considerations and should not be entertained.

Another way of looking at this situation is that TPG Telecom has spectrum, has decided to not invest further in infrastructure in regional Australia, and is seeking to find a way forward.

If the government's view is that Telstra, Optus and TPG are expected to have separately operated mobile networks, then it would hold that the government is expecting the ACCC to enforce the spectrum limits; otherwise, the competitive tension in the mobile telecommunications market could be significantly diminished.

But what about in an area where one carrier does not operate a network and has made the decision that it is not economically viable to install competing infrastructure?

To utilise the spectrum that it holds, TPG has made the decision to seek an arrangement that permits the spectrum to be used in an area where it would otherwise not operate or not fully gain the benefits afforded by the spectrum holding.

As identified earlier, the ACCC's failure in 2018 to identify this inevitability has likely led us to this point.

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Services

Whilst an outcome of the proposed MOCN commercial arrangement would be the introduction of TPG 4G and 5G services in the Regional Coverage Zone, there are factors related to the services that should be considered.

The TPG service charges will include a component set by Telstra that is offset by the Spectrum Authorisation Agreement, and a Mobile Site Transition Agreement. Whilst it is not unusual for a network operator to lease access to infrastructure and facilities, the proposed arrangement may be unusual because of the quantum of what is proposed, the unknown value of the Spectrum Authorisation Agreement and the effect that it may have on future TPG product pricing.

Public Benefit

The MOCN commercial arrangement would have an immediate public benefit with the introduction of TPG 4G and 5G services in the Regional Coverage Zone. This would permit existing TPG customers to utilise their mobile devices in the Regional Coverage Zone and, for residents and businesses within the Regional Coverage Zone, the opportunity would exist to select TPG as their mobile service provider.

For Telstra, the MOCN commercial arrangement would significantly boost its regional network, both in size and value. With more customers utilizing this network, the infrastructure cost per customer reduces and profitability increases.

There is also the benefit for Telstra that the Spectrum Authorisation Agreement could potentially enhance the performance of the mobile network, but only if additional capacity is supplied to the existing network.

Effectively, only two carriers would now be bidding for mobile blackspot funding in the Regional Coverage Zone. It is anticipated that an increasing share of the mobile blackspot funding will be delivered to Telstra, thereby further enhancing Telstra's dominant infrastructure and transit position in regional and remote areas.

At some point, if not already, Telstra could become a regional and remote mobile telecommunications monopoly infrastructure and transit provider, particularly if Optus withdraws from or reduces its investment in regional mobile telecommunications.

As discussed earlier, a hypothetical mobile telecommunications market where there are three networks operated by three carriers with roughly equivalent spectrum holdings was always unlikely in regional and remote Australia.

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The ACCC has demonstrated difficulty grasping this reality. It is now time for the ACCC to adopt an alternate approach to foster competition in the regional mobile telecommunications market.

Throughput (capacity)

Recommendation Seven of the 2021 Regional Telecommunications Review Report (RTR, 2021) highlights an area of significant concern regarding regional telecommunications. The recommendation calls for government to develop and enforce "minimum wholesale and retail service, performance and reliability standards appropriate for each service type (fixed and landline, mobile, fixed wireless, satellites)".

A potentially significant public detriment could occur if Telstra does not increase the data throughput (capacity) made available at its mobile base stations, by upgrading the capacity of the access network and its backhaul network. With an increase in customers at each mobile base station due to TPG customers using Telstra's network infrastructure, there would be a requirement for a corresponding increase in data throughput (capacity).

The government has committed to a $20 million independent national audit of mobile coverage, commencing in 2022 (Albanese, 2022).

Small network operators

In regional and remote areas small network operators currently enter into agreements with carriers to utilise unused spectrum holdings. This normally occurs in sparsely populated areas where the spectrum holder has no plans to provide services themselves. This is an opportunity that has fostered growth in the regional small network operator market. Small network operators provide a vital service in regional and remote areas and are often the only technical people available in local communities to provide specialised telecommunications advice, services and assistance.

There is a strong likelihood that the proposed MOCN commercial arrangement will result in existing small network operators having spectrum withdrawn or reduced, even in areas where the spectrum is not used and will never be used by the spectrum holders.

Whilst the regional small network operators are not guaranteed access to spectrum as they are not the license holder, the potential for Telstra or TPG, or both, to act to further reduce competition in regional and remote areas by restricting access to this unused spectrum is high. This would be a highly detrimental outcome for local communities in regional and remote areas.

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Optus

For Optus the proposed MOCN arrangement between Telstra and TPG is likely to be highly undesirable. If the merger authorisation is approved, Optus is expected to challenge the decision in court, as Optus could argue that the MOCN arrangement significantly alters the nature of competition in the mobile telecommunications market in the Regional Coverage Zone and beyond. Optus may also seek damages against the Commonwealth for potential losses related to a decision by the ACCC that detrimentally affects its future earnings potential.

Whilst market dynamics cannot be predicted, if, as a result of the MOCN arrangement, Optus loses market share or the value of its infrastructure investment in regional and remote areas diminishes, it could be forced to universally raise product charges.

The flow-on effect could have a significantly detrimental effect on the MVNOs that utilise the Optus network. Similarly, this could mean higher product charges for affected MVNOs. It is also likely to negatively impact existing MVNOs who utilise TPG's spectrum holdings in regional areas, where Telstra will have the authority to direct TPG to block access to reduce competition.

It is important for the ACCC to identify that the proposed MOCN arrangement is not expected to spur further investment by Optus or any other carrier in regional and remote areas. Current investment in infrastructure in regional and remote areas by Optus highlights that it is carefully selecting locations where customer density (whether this is permanent residents and businesses, or transitory tourists) and access to price regulated non-Telstra transit is such that the investment is justified.

Alternatives

It is reasonable for the ACCC to consider alternatives that might provide a more balanced competitive outcome. The alternatives could be put to the carriers for comment, as they might provide valuable input when the ACCC considers the MOCN arrangement.

A declaration of domestic mobile roaming in regional and remote areas would be inclusive of all mobile network operators, would facilitate infrastructure and spectrum sharing arrangements, and would be price regulated. Further, despite Telstra's protestations, there is no evidence to suggest that this declaration would thwart or stop investments in regional areas.

A condition that Telstra splits into two companies (retail and wholesale) that are separately listed legal entities could provide a similar outcome to a declaration of domestic mobile roaming in regional and remote areas. The new wholesale entity would include (but not be

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limited to) infrastructure and transit resources needed to provide mobile telecommunications in regional and remote areas.

If the ACCC decides to deny the merger authorisation, the ACCC must not make the mistake that a resumption of the status quo is acceptable, because not only would the benefits of the MOCN arrangement be lost, but also the telecommunications market would not become open and competitive in regional and remote areas.

Telstra's recent change to its business model, where it has split into three segments, two of which are aimed at 'reselling' their fixed and mobile infrastructure, is resulting in a significant change in market dynamics. The Telstra-TPG MOCN agreement is an example of how Telstra's infrastructure holdings, if properly regulated, could be a game changer for regional telecommunications. This warrants strategic telecommunications reviews by the government and the ACCC of what legislation and regulations are needed in this new environment; and domestic roaming, particularly in regional areas, should be a significant element of the reviews.

The 2021 Regional Telecommunications Review Report (RTR, 2021), with its long list of recommendations, highlights that the ACCC must act to improve regional mobile telecommunications outcomes.

Recommendations

The following recommendations are made.

If the ACCC approves the MOCN arrangement:

1. A condition be set that Telstra Corporation is to split into two legal entities (retail and wholesale) separately listed on the ASX with independent share registries and boards. The entities would voluntarily agree to not hold shares amounting to more than twenty per cent of the other entity's shares. The new wholesale entity would own infrastructure, facilities and transit needed (as a minimum) to provide mobile telecommunications in regional and remote areas.
2. A condition be set that Optus be invited to participate.
3. A condition be set that access and other charges be price regulated in areas where there are fewer than two alternate third party infrastructure and transit providers.

If the ACCC does not approve the MOCN arrangement:

1. Alternative approaches are required that permit Telstra, Optus, TPG, small regional network operators, and the MVNOs to competitively provide improved mobile telecommunications to regional mobile telecommunications consumers, ensuring that

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Telstra is not permitted to place restrictions on access to TPG's spectrum holdings by third-party MVNOs.

2. A new domestic mobile roaming inquiry be commenced.

Conclusion

This paper has considered the application for merger approval from Telstra Corporation Limited and TPG Telecom Limited related to three interrelated agreements that would put in place a MOCN arrangement. There is a strong linkage between the ACCC's decision in 2018 to not declare domestic mobile roaming and the application for merger put to the ACCC by Telstra and TPG. Telstra and TPG are acting in the best interests of their shareholders.

The question of likely public benefits versus public detriment is vexed, because mobile telecommunications in regional and remote areas has not enjoyed an open and competitive environment, due to how telecommunications deregulation has occurred in Australia. Public funding and mobile blackspot funding over past decades has further diminished competition in regional and remote areas by channelling public money to Telstra, further distorting and unbalancing the market.

If the application for merger is to be approved by the ACCC, then conditions should be placed upon what is permitted. If the application for merger is not approved by the ACCC, then alternative arrangements should be established immediately to provide a more balanced, open and competitive outcome that does not exclude Optus and MVNOs that access the Optus network or MNVOs that currently access the TPG/Vodafone network.

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