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Infrastructuring of Digital Platforms:
A Configurational Analysis

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ABSTRACT

Digital platforms expand into multiple adjoining business domains for revenue maximization purposes. Governments also use digital platforms for public welfare in multiple interrelated sectors. Such horizontal growth transforms digital platforms as digital infrastructure which consequently increases its e-adoption. This research determines combinations of platform attributes which drive the infrastructuring of digital platforms. Results of this research will enable platform mangers to, a priori, embed such attributes in platform architecture to achieve platform objectives. Fuzzy-set qualitative comparative analysis (fsQCA) research methodology followed by a descriptive cross-analysis has been used in this research. Five key result sets emerge, which, inter alia, indicate that criticality, ubiquity, and generativity are key attributes driving the infrastructuring of digital platforms, unlike earlier research results showing modularity and heterogeneity as key attributes. fsQCA research method with a set theory approach is more suitable for such configurational analysis compared to multivariate techniques.

KEYWORDS

Digital Infrastructure, Digital Platform, E-Adoption, Fuzzy State Qualitative Comparative Analysis

INTRODUCTION

During a widespread outage of some of the popular social media digital platforms like Facebook, Instagram, and WhatsApp on October 4, 2021, from 1600h GMT to 2200h GMT[1], approximately 3.5 billion users worldwide were cut off from their social media-based global connectivity. The outage resulted in an estimated financial loss of $7 billion[2] over the six-hour period. This incident serves as a symbolic reflection of the criticality and dependency of society on such digital platforms.

Digital platforms like Facebook, Google, and Android are important information technology artifacts of modern times. These platforms are defined as software-based entities consisting of an extensible codebase, allowing developers to create complementary modules using interfaces and boundary resources provided by the platform owner (Tiwana, 2015). Digital platforms are also known as multisided entities, facilitating interactions between platform owners, sellers, and buyers. Most

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digital platform business firms are global leaders in their respective business domains[3] like Facebook in social media and Android in mobile operating systems.

Similarly, infrastructures are another crucial element of modern society. Infrastructure is defined as "a substructure or underlying foundation; the basic installations, which are critical for continuance and growth of a community, state, or a corporate entity" (Dawson, 2013, p. 4). Examples of widely known physical infrastructures include roads, rail, power plants, transportation systems. Digital infrastructures, in contrast, encompass computing and network resources that allow multiple stakeholders to fulfill their service and information content needs in digital format. These infrastructures are critical for the survival and functioning of societies or corporations. Examples include the internet, Global Positioning Systems (GPS), and smartphones (Constantinides et al., 2018).

In the recent past, several leading authors in Information Systems (IS) research area, have highlighted the phenomenon of popular digital platforms transforming into digital infrastructure (Constantinides et al., 2018; De Reuver et al., 2018; Plantin & De Seta, 2019). This phenomenon holds immense importance for both business and society. In the business domain, the transition of digital platforms into infrastructure has the potential to significantly boost the revenue of the respective business entities. Moreover, in the societal domain, digital infrastructures play a crucial role in sustaining the economic growth of nations in the contemporary global order (Zhou, 2022).

In addition, the infrastructuring of digital platforms leads to increased adoption of such artifacts in society by removing adoption barriers (Hanseth & Lyytinen, 2016). This research seeks to address fundamental questions regarding the factors and attributes that drive the infrastructuring of digital platforms in the business domain. There are three key research needs for such analysis.

First, leading digital platforms, driven by a revenue maximization strategy, often expand into adjoining business domains (Constantinides et al., 2018). For instance, companies like Facebook and Google have expanded into fields like advertising, digital publishing, marketing, analytics, and entertainment. Due to horizontal expansion into adjoining domains, these digital platforms have transformed as digital infrastructures of modern society (De Reuver et al., 2018).

Taking Google as an example, Plantin et al. (2018) argued that both Google maps in the Geographical Information System (GIS) domain and Google Search in the information retrieval domain have achieved extraordinary global reach. This is further supplemented by digital platform-based innovations which are built upon these systems, resulting in a further increase in their widespread usage. Thus, transformed digital platforms like Google Search and Google Maps, possess infrastructure characteristics and acquire significant societal value in these respective domains. These platforms are now critical to society and serve as the global benchmark in their respective fields. Understanding this infrastructuring phenomenon of digital platforms is the first research need .

Second research need arises from a necessity to ascertain the drivers causing infrastructuring of digital platforms. This is important as infrastructures have a critical role in nation-building, akin to traditional physical infrastructure like rail, road, and power grid systems (Greenstein, 2021). Understanding the drivers of infrastructuring in advance can empower designers and business managers, pursuing revenue maximization goals, to embed such features into digital platforms from the outset, facilitating their eventual transformation into digital infrastructures.

The evolution of digital platforms into infrastructure signifies their transformation into digital infrastructure as a public good (De Reuver et al., 2018). This shift has led to the emergence of discourse surrounding Digital Public Infrastructures (DPIs) in different countries, highlighting the infrastructuring of digital platforms in social sector applications.

DPIs are shared infrastructures that provide equitable access to all members of society, enabling layered innovation and decentralized work to fuel economic growth of society (Raghavan et al., 2019). A prior knowledge of the factors that shape digital platforms into infrastructures can aid the creation of DPIs and contribute to a nation's economic growth. Public policymakers can leverage this understanding to encourage platform architects to design digital platforms with attributes that facilitate the creation of DPIs.

The third research need arises from the fact that infrastructuring of digital platforms leads to its increased usage and adoption in society (Verdecchia et al., 2022), which should be researched in societal interest. Understanding the attributes that drive infrastructuring can inform the design of digital platforms, facilitating their increased adoption in society. This underscores the significance of such research for both business and societal purposes.

In all three cases, if the drivers of digital platform infrastructuring are known in advance, they can be embedded into platform design, contributing to the platform's business growth while simultaneously providing critical infrastructures for society. Therefore, the research objective is to ascertain the factors and drivers enabling the transformation of digital platforms into infrastructures.

LITERATURE REVIEW

In pursuit of the research objective, a literature review was carried out using the keywords "digital platforms," "digital infrastructure," "adoption," and "e adoption" across leading research databases like ProQuest, EBSCO, Emerald Insight, and Google Scholar), covering a period of 13 years (2010–2023). The results can be categorized into four distinct themes.

The first theme identified in the literature review is about the growing convergence between digital platforms and digital infrastructures. Despite their distinct characteristics, both systems grow over time, with digital platforms expanding into neighboring business domains and gradually transforming into digital infrastructure (Constantinides et al., 2018). Helmond et al. (2019) examined Facebook's transformation from a social media platform to a digital infrastructure by diversifying into fields like advertising, marketing, analytics, and publishing. Earlier studies by Constantinides et al. (2018) and Plantin et al. (2018) discussed similar infrastructuring phenomenon for Amazon and Google, respectively. Infrastructuring has been associated with open authorization (OAuth) and Application Program Interface (API)-based integration between digital platforms (Evans & Basole, 2016). As control arrangements become more open, there is a greater convergence between platforms and infrastructures, needing further investigation by future IS researchers (De Reuver et al., 2018).

The second theme identified in the literature review is regarding the phenomenon of infrastructuring of digital platforms, happening across different industries and social settings. Researchers have explored this phenomenon in diverse contexts, highlighting its occurrence across multiple industries and business settings. For example, Kazan et al. (2018) examined the infrastructuring of digital payment platforms in the United Kingdom, while Andrade et al. (2021) studied Internet of Things- (IoT) based digital platforms. Spagnoletti et al. (2015) examined digital healthcare platforms, and Tan et al. (2015) researched Multiple Service Platforms (MSPs) with Alibaba as case study. Mukherjee (2019) investigated Indian 4G telecom platform services provided by Reliance Jio as digital infrastructures. Additionally, Gehl and McKelvey (2019) studied the infrastructuring of darknet platforms like Tor, Freenet, and the Invisible Internet Project (IIP). These authors concluded that infrastructuring is a natural progression for digital platforms aimed at value creation and enhancement.

The third theme identified in the literature review is about impact of infrastructuring of digital platforms on the adoption rate of information technology artifacts in society. Greenstein (2021) examined the adoption rate and different factors influencing the adoption of the internet as infrastructure, concluding that infrastructuring leads to higher adoption rates of such artifacts. The author contended that non-adoption is not due to economic causes but rather to the lack of proper policies, recommending more research on adoption factors for infrastructures. Hanseth and Lyytinen (2016) examined digital infrastructures and argued that infrastructuring leads to the dismantling of adoption barriers. Verdecchia et al. (2022) examined sustainable digital infrastructures and identified several critical adoption factors, including the ease of integration of such infrastructures. Additionally, De Reuver et al. (2018) emphasized that the infrastructuring of digital platforms results in a positive feedback cycle, resulting in enhanced usage of such platforms.

The fourth theme identified in the literature review emerges from new recent research literature on the subject of infrastructuring of digital platforms, which have been published between year 2018 and 2023. This theme encompasses two distinct topics that have emerged in recent research.

The first topic revolves around the widespread acceptance of the fact of digital platforms evolving into critical infrastructures of the modern age, with their increased usage being essential for both corporate and societal purposes. For example, Busch (2022) examined the impact of such infrastructuring on public digital services platforms, while Pierson (2021) conducted an impact analysis of infrastructuring on digital messaging platforms. Both authors observed that digital platforms, as infrastructures, have become critical for society. Additionally, Beveregun et al. (2022) examined the infrastructuring of cloud-based digital platforms like Google and open platforms like the European Union's GAIA-X. Meanwhile, Jiang and Murman (2022) examined the impact of infrastructuring on the Chinese digital economy, and Palmer et al. (2022) researched the impact of infrastructuring on digital payment platforms. Other studies, such as those by Nubel et al. (2022) on federated digital platforms, Joglekar et al. (2022) on digital platforms' infrastructuring in value chain system, and Stehlin and Payne (2022) on the infrastructuring of micro mobility transport digital platforms further underscore the increasing trend of infrastructural transformation of digital platforms.

The second topic emerging from recent research literature is regarding increased emphasis on a need to ascertain the attributes that enable the infrastructuring of digital platforms. Authors argue that due to its criticality, the research community should focus on discovering the essential elements that drive digital platform infrastructuring phenomena (Constanatinides et al., 2018). Earlier, Henfridsson and Bygstad (2013) argued that determining the causal reasons for infrastructuring would be highly valuable for managers and IT professionals confronted by the complexity of managing these digital platforms. De Reuver et al. (2018, p. 7) observed that "some platform strategies are aimed at infrastructuring the digital platform, as in the case of the Facebook OAuth authentication platform" and called on researchers to ascertain attributes necessary for such infrastructuring processes. Another notable research paper in this regard is Mukhopadhyay et al. (2019), who established that modularity and open standards are essential attributes to enable scalable digital infrastructures. Hein et al. (2020) observed that malleability and openness attributes are helpful in the infrastructuring of digital platforms leading to new digital affordances. Earlier, Kenney and Zysman (2019) observed digital platforms' cloud-based capabilities as key characteristics that enable infrastructuring. Tilson et al. (2010) and, almost a decade later, Constantinides et al. (2018), also recommended that, in view of the increased phenomenon of infrastructuring of digital platforms, there exists a research need to determine those features of digital platforms which enable infrastructuring. However, apart from the two research papers mentioned above (Hein et al., 2020; Mukhopadhyay et al., 2019), not much research literature exists that dwell on actual determination of the key attributes enabling infrastructuring of digital platforms. This research attempts to address this research gap.

Research Gap and Research Question

As highlighted in the literature review, leading academicians and scholars have urged the research community to identify the attributes driving the infrastructuring of digital platforms (Constanatinides et al., 2018; De Reuver et al., 2018; Henfridsson & Bygstad, 2013). The transformation of digital platforms into digital infrastructures is a gradual evolutionary process, as described by Star and Ruhelder (1996, p. 4): "Do not ask *what* an infrastructure is but *when* it is an infrastructure." This prompts the question of which attributes or characteristics of digital platforms drive their transformation into infrastructures. As digital platforms expand into adjacent business domains, platform owners need to be aware of the essential attributes that facilitate integration across multiple domains and ultimately acquire digital infrastructure characteristics. However, not every digital platform automatically acquires infrastructure characteristics. Moreover, such attributes do not act in a a standalone manner but as part of a set of particular combination of attributes to drive infrastructuring

(Henfridsson & Bygstad, 2013). It has been argued that digital infrastructure evolution is primarily caused by more than one configuration of possible attributes as a conjectural explanation (Fiss, 2007; George & Bennett, 2005). Yet, this issue remains unaddressed in existing research literature. While a few research papers have examined this issue, they have determined such attributes in standalone configurations, failing to address the issue from a configurational conjectural standpoint. This gap represents a critical area in the otherwise exhaustive digital platform research literature.

The significance of examining the drivers of infrastructuring becomes more important as infrastructuring leads to increased adoption of such platforms in society. Understanding the necessary and sufficient number and combination of attributes that facilitate infrastructuring of digital platforms can aid in their transformation into digital infrastructures, thereby fostering business growth and profitability (Greenstein, 2021). Moreover, digital platforms transformed into digital infrastructures also facilitate national economic growth and act as societal public goods, underscoring the importance of knowledge regarding the attributes driving infrastructuring in nation-building efforts (Sarangi & Pradhan, 2020). Accordingly, this research aims to address the following research question:

WHAT CONFIGURATION OF ATTRIBUTES DRIVES INFRASTRUCTURING OF DIGITAL PLATFORMS?

Theoretical Lens

In any social science study, the research question needs to be understood and analyzed in terms of a theoretical framework to provide a reliable foundation for further research design (Grant & Osanloo, 2014). As explained, the research question pertains to identifying the drivers of digital platforms that enable their transformation into digital infrastructures. To answer this question effectively, it is essential to base the research on a theoretical foundation that best explains the behavior of digital infrastructures. Both digital platforms and digital infrastructures are analyzed as complex systems in this research (Abbot, 2007; Henfridsson & Bygstad, 2013).

In Information Science (IS) research, order emerges through the interactions of organisms or agents. These "agents" represent semi-autonomous entities like technologies, processes, people, groups, firms, and industries (Ferber & Weiss, 1999). The integration of heterogenous elements into a coherent system characterizes digital infrastructures within the complexity paradigm (Hanseth & Lyytinen., 2016). First theory used in this research is the theory of large technical systems or LTS (Hughes, 1987). As per this theory, infrastructures are like networks of interrelated components and subcomponents with different functions and natures, forming national or global systems with common institutional and socio-technical objectives (Edwards et al., 2003). Adopting the LTS theory enables the definition of digital infrastructures as compositions of heterogenous elements interconnected through generic or meta-generic gateways, open and reconfigurable at their boundaries, and operating as coordinated systems.

This system-based definition of digital infrastructures, rooted in the LTS theory, has led several authors to recommend that digital infrastructures be examined from a configurational perspective rather than focusing on individual factors and variables (Hanseth & Lyytinen, 2016; Henfridsson & Bygstad, 2013). Accordingly, this research adopts a configurational approach to analyze the transformation of digital platforms into digital infrastructures.

Another theoretical lens applied in this research is the theory of infrastructure criticality propounded by Bowker and Star (1999). This approach emphasizes the interacting dependencies that are created within a society when any system becomes infrastructure. Such criticality gives rise to social chaos and breakdown once infrastructures fail. When examining the infrastructuring of digital platforms from this perspective, it emphasizes the potential social dependencies created once platforms undergo transformation into infrastructures.

SELECTION OF CANDIDATE ATTRIBUTES BASED ON THEORETICAL LENS AND LITERATURE REVIEW

As the research question shows, this study seeks to find attributes that drive the infrastructuring of digital platforms. Such characteristics, named candidate attributes in this study, were selected through a two-stage process. In the first stage, several digital platform attributes were chosen based on the theoretical lenses used, named the theory of LTS and infrastructure criticality. Subsequently, for each selected digital platform candidate attribute derived from the theoretical lenses, relevant research literature was consulted to ascertain whether the attribute has been described as a contributing factor to the infrastructuring of digital platforms. Those attributes of digital platforms taken in the first stage but not referred to specifically in extant research literature as factors contributing to infrastructuring were excluded. Following these selection and elimination stages, the final list of candidate attributes was compiled (see Table 1).

The first digital platform attribute considered to drive infrastructuring, selected in stage 1, is heterogeneity. This attribute is a candidate attribute based on the theory of LTS (Holland, 2014). Subsequently, in the stage 2 selection process, heterogeneity has been referred to in extant research literature as an important component of digital infrastructures (Hanseth & Montario, 1997; Yoo et al., 2012). Heterogeneity is defined by authors as the use of a wide range of equipment, diversity of information resources produced by these devices, and the variety of applications and software that use these diverse information resources, all within a network of standards produced by multiple actors, organizations, and technologies associated with digital systems. Thus, heterogeneity is a suitable candidate attribute for subsequent analysis.

Based on the complexity paradigm and the theory of LTS, another candidate attribute is essentiality. Essentiality is defined as a relational characteristic of an artifact, deemed as the most feasible and practical option as compared to other possible options (Hermes et al., 2022). Although essentiality is based on the complexity theory (stage 1), there is limited research literature indicating it as a factor causing digital infrastructuring (stage 2). Hence, essentiality is discarded as a candidate attribute based on the considerations of stage 2 attribute selection.

Openness, predominantly concerning the use of open standards and interfaces (Tiwana, 2015), is another candidate attribute. It is drawn directly from the theory of LTS (stage 1) and is, therefore, considered a contributing factor to infrastructuring of platforms (Holland, 2014). Openness has been referred to as a source for infrastructuring in various research literature (stage 2). For instance, Hanseth and Monterio (1997) described openness as a platform feature fostering an ecosystem devoid of restriction or proprietary control over users, stakeholders, vendors, network nodes, technological components, application areas, or network operators, achieved through open standards, protocols, and gateways. Hence, openness is considered a candidate attribute for further research.

Similarly, generativity, another platform attribute rooted in the complexity paradigm of infrastructural research (stage 1), has been considered as contributing to the infrastructuring of platforms (Holland, 2014). In stage 2 selection, generativity has been identified as promoting innovation, thereby enabling the infrastructuring phenomenon (Yoo et al., 2012). Platforms leverage the generativity of ecosystems to enable complementors to actualize digital affordances, leading to the development of unforeseeable functionalities beyond the capabilities of the platform owner (Hanseth & Monterio, 1997). Thus, generativity is considered a candidate attribute for further research.

Scalability, another candidate attribute, is directly related to the theory of LTS (Hughes, 1987). It is a critical agent in the infrastructuring of digital platforms. Scalability has been held as a major attribute of digital infrastructure in various research literature (Mukhopadhyay et al., 2019; Tilson et al., 2010). Hence, scalability is considered a candidate attribute for further research.

The next digital platform attribute, emerging from the complexity paradigm and based on the theory of LTS, is modularity (stage 1). Further, modularity has been recognized as an essential

Table 1. Final List of Candidate Attributes With Associated Theoretical Lens and Literature

Infrastructural Studies Research Stream	Foundational Theory	Reference Literature	Digital Platform Attribute Enabling Infrastructuring	Definition	Reference Literature
Complexity	Theory of LTS Infrastructures result from interconnection of many nodes and elements, with varied architecture, scalable in nature, loosely coupled, coordinated and having sociotechnical underpinnings	Van Der Vleuten (2009)	Heterogeneity	An attribute created due to usage of a range of equipment, diversity of information resources which these devices produce, application and software which use these diverse information resources using variety of network and standards produced by multiple actors, organizations and technologies associated with digital systems.	Hanseth and Monterio (1997)
			Openness	Openness to platform feature where there is no limits and restrictions for number of user, stakeholders, vendors involved, nodes in the network and other technological components, application areas or network operators interacting through open standards, open protocols and open gateways	Hanseth and Monterio (1997)
	Theory of LTS		Generativity	Defined as ability due to which digital systems leverage ecosystems' generativity so that complementors can actualize digital affordances to develop unforeseeable functionalities beyond the platform owners' capabilities generativity attribute promote innovation which, in turn, enables infrastructuring phenomenon (Yoo et al, 2012).	Hanseth and Monterio (1997)
			Scalability	Ability to perform with same degree of efficiency when user base is increased much significantly	Walsham and Sahay (2006)
			Modularity	A modular architecture is characterised by its focus on the interfaces between components and the encapsulation of the functionality of each component as an independent unit. Modularity is a general design principle that intentionally increases independence among the subsystems of a complex system	(Sanchez and Mahoney, 1996)
Network relational	Theory of Infrastructure Criticality Digital infrastructures evolve as meaningful and essential aspect of social structures	Callon, 1986	Ubiquity	Manifoldness in other markets and industries to the extent that it is widely available, shared and is indispensable.	Helmond, Nieborg, and Der Vlist (2019)
		Bowker and Star (1999)	Criticality	An attribute which makes an asset or system essential for the maintenance of vital societal functions. The damage to a critical infrastructure, its destruction or disruption may have a significant negative impact society and citizens	Star and Ruhelder (1996)

infrastructuring attribute by authors like Henningsson and Eaton (2023) (stage 2). Hence, modularity is considered a candidate attribute for further research.

The next two digital platform attributes, criticality and ubiquity, are derived from the theory of infrastructure criticality, respectively (stage 1). Several authors have observed the association of criticality and ubiquity with digital infrastructures (Helmond et al., 2019; Scholl & Patin, 2014). Therefore, both criticality and ubiquity are considered candidate attributes for further research.

Adaptability is another attribute that emerges from the theoretical lens in this research. Chester and Allenby (2019) defined adaptability as the capability of complex systems to adjust their structure in emergent situations. Upon closer examination, this attribute is similar to the generativity attribute in its application in complex systems like digital platforms.

In this way, seven digital platform attributes are considered for further analysis for driving infrastructuring of digital identity platforms (see Table 1).

RESEARCH METHODOLOGY

The infrastructuring of digital platforms cannot be analyzed by focusing solely on individual platform attributes acting in standalone mode . Instead, it is recommended to be examined using a configurational approach from an organized complexity perspective (Park & Mithas, 2020). Similar recommendations to analyze digital infrastructure using a configurational approach have been made by Henfridsson and Bygstad (2013) and Fiss (2007). This is because digital platforms are complex objects and their attributes have nonlinear interactions with each other. Therefore, in this research, fuzzy-set Qualitative Comparative Analysis (fsQCA) have been used to examine the research question. Input data for fsQCA has been prepared as quantitative indices using the trapezoidal fuzzy arithmetic method (Sriramdas et al., 2014).

fsQCA, a type of qualitative comparative analysis (QCA) research tool, combines the strengths of both qualitative and quantitative methods (Ordanini et al., 2014). Launched by Ragin (1987), QCA is based on a configurational approach rooted in set theory principles. Unlike conventional quantitative methods that analyze the impact of individual variables on outcomes while keeping other variables constant, QCA focuses on identifying combinations of variables within a set or configuration that influence the outcome variable. In fsQCA, variables can take fuzzy values between 0 and 1, representing a nuanced representation of the gradual transformation of digital platforms to digital infrastructure. This contrasts with Crisp Set QCA, where variables are binary (0 for no infrastructuring and 1 for full infrastructuring). fsQCA results may be further substantiated using contextual and case-based knowledge. Thus, QCA is an inference-oriented research method, leveraging existing knowledge to predict the unknown, particularly suitable for analyzing complex systems like digital platforms (Park & Mithas, 2020).

The fsQCA research method is based on certain foundational principles, with the concept of organized complexity being paramount amongst these (Ragin,1987). This concept is much suited for studying the transformation of digital platforms, which are complex objects well-suited for consideration within the framework of organized complexity (Abbot, 2007). Digital platforms and their evolution into digital infrastructure are characterized by characteristics like non-linearity, non-additivity, and non-probabilistic interactions. These interactions, when combined, are not only unpredictable but also rule out any permanent causation with a moderate number of variables influencing the outcome.

Other basic principles of fsQCA include the configurational approach, where conditions impacting an outcome are regarded as configurations of interrelated structures rather than isolated entities. Conjunctural logic is also essential, representing a nonlinear, nonadditive, and non-probabilistic conception that rejects permanent causality. Equifinality is another principle, acknowledging that different combinations of independent variables can lead to the same outcome. Additionally, causal asymmetry is recognized, meaning the presence of a cause leads to the presence of the effect, but the absence of the cause may not lead to absence of the effect (Glaesser, 2021; Pappas & Woodside, 2021).

Reasons of Selecting fsQCA Over Conventional Quantitative Methods for This Research

There are six main reasons for selecting fsQCA over conventional quantitative method for this research. First, digital platforms exhibit complex systems characteristics with nonlinear and asymmetric dependencies within their ecosystem (Bonina et al., 2021), making bivariate quantitative methods insufficient. fsQCA, with its configurational approach, is suited for analysis of complex dynamics of digital platform ecosystems (Park & Mithas, 2020).

Second, the complexity of digital platforms is considered through the lens of organized complexity rather than random Brownian complexity. Pappas and Woodside (2021) recommended the application of QCA-based methods to analyze systems characterized by such organized complexity.

Third, traditional quantitative methods, which rely on correlation analysis, assume symmetry between variables and are not well-suited for analyzing cases of causal asymmetry. An infrastructuring of digital platforms is asymmetric in nature, with some factors driving infrastructuring more effectively than others. The absence of these factors may not necessarily preclude infrastructuring entirely. Set theory-based configurational methods like fsQCA can better explain causal asymmetry (Glaesser, 2021).

Fourth, the infrastructuring of digital platforms, in this research, is based on datasets derived using purposive sampling, which do not necessarily support conditions like noncollinearity and homoskedasticity. These conditions are essential for conventional quantitative research methods, which typically use databases based on random but representative selection.

Fifth, it is desirable to ascertain both necessary and sufficient conditions for this research problem, namely, to ascertain the drivers of infrastructuring of digital platforms. Conventional quantitative methods are unable to identify both necessary and sufficient conditions, whereas QCA facilitates the process.

Sixth, QCA methods can be applied even to a moderate-sized database (Greckhamer et al., 2018; Pappas & Woodside, 2021). Given that this research is based on a purposive sample of moderate size, it is more suited for analysis using a set theory and Boolean algebra-based configurational method like fsQCA with a smaller database size (Pappas and Woodside, 2021).

Data Source and Data Preparation

To apply the configurational perspective, as per requirements of the fsQCA method, the candidate attribute values of digital platforms under examination need to be transformed into quantitative indices for the research dataset to enable subsequent quantitative analysis. This transformation is carried out in three substages.

In the first substage, qualitative data are collected from design documents available on the official websites of 21 popular digital platforms, forming the research dataset. Only digital platforms and systems with a large global footprint have been selected for inclusion, as they have the potential for infrastructuring (Hanseth & Lyytinen, 2016). Purposive sampling, recommended for use in QCA research, has been employed due to its representativeness, lack of bias, and reduction in time and cost regarding data collection (Ragin, 2008). These digital platforms include social media digital platforms (Facebook, Google, Whatapp, Alibaba etc.), Operating systems (Andorid, Microsoft Windows etc.), E commerce and mobility and hospitality digital platforms (Amazon, Air BnB, Uber etc.) and several such digital platforms.

In the second substage of data preparation, the relevant text is qualitatively categorized by a group of expert coders into four classes—very high, high, medium, and low—for each of the selected seven digital platform attributes for these 21 digital platforms. Details regarding the coders and domain experts are summarized in Table A.1 (Appendix).

In the third substage of data preparation, the qualitative data are converted into numerical indices suitable for input to fsQCA. The trapezoidal fuzzy arithmetic method has been used in this research

(Sriramdas et al., 2014) for this purpose. In this method, the quantification of an attribute is achieved by giving different weights to classifications (given earlier in substage 2 by coders) depending on their experience and domain expertise. The degree of infrastructuring of the platform is also coded as input. The results, presented as quantitative indices for each of the seven variables, are given in the Appendix (Table A.2).

These quantitative indices need to be checked for reliability and validity as they have been obtained by using a transformative process following trapezoidal fuzzy arithmetic (Sriramdas et al., 2014). As fsQCA does not provide a method for checking the validity and reliability of the dataset, IBM SPSS and R software were used for such tests.

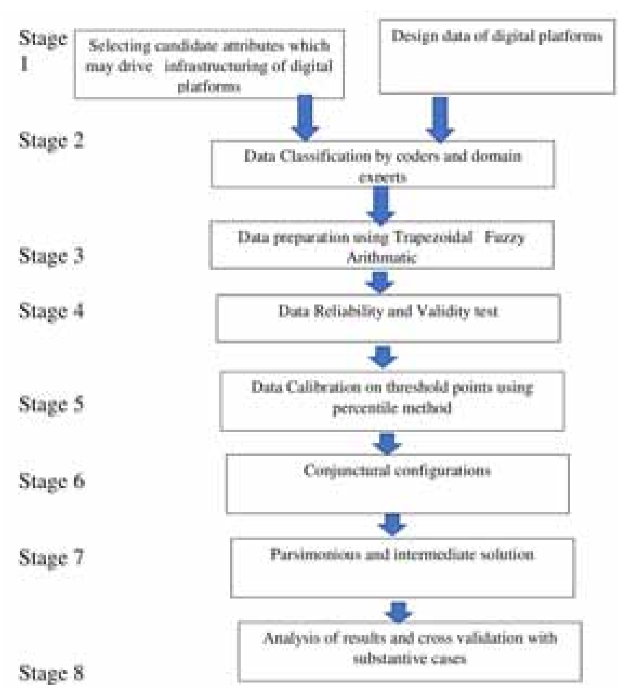
For the validity test of the data, Kendall Tau correlation coefficient was determined using R software. This correlation coefficient was chosen primarily because it does not need the database to be normalized, which is the case in this research. Each of the variable correlations was found to be below the benchmark value of 0.80, indicating acceptability.

For the reliability test, Cronbach's alpha value was determined using IBM SPSS. An acceptable value of Cronbach's alpha (0.846) was obtained for the research dataset, which surpasses the cut off threshold of 0.7, rendering it acceptable. The results show that the variable correlations are below the accepted benchmark of 0.80. The results of are given in Appendix Table A.3.

fsQCA Process Block Diagram

After the dataset is fully prepared and the reliability and validity of this dataset have been established, the fsQCA method is applied to determine configurations of digital platform attributes driving infrastructuring. The fsQCA process, as applied in this research, is explained through a block diagram (see Figure 1). The first four stages of the block diagram in Figure 1 pertain to selection of candidate attributes, data classification and coding, data preparation into quantitative indices using trapezoidal

Figure 1. Block Diagram Showing fsQCA Process



fuzzy arithmetic, and reliability/validity tests, as explained in earlier sections. Stage 5 (block diagram Figure 1) involves the calibration of the dataset.

The calibration of the dataset implies that numerical indices with a value between 1 and 10 (obtained in the data preparation stage) are converted to fuzzy value (between 0 and 1) for use as input in the fsQCA process. A calibrated score of 1 indicates full membership of the outcome set, while a score of 0 implies no membership. A score of 0.5 is the middle cross-over point. Greckhammer et al. (2018) advocated for calibration anchor points to be half empirical and half conceptual based on the researcher's contextual knowledge. In view of the gradual and continuous process of infrastructuring of digital platforms, calibration anchor points are benchmarked at threshold values of 0.05, 0.95, and 0.50 for full non-membership, full membership, and the cross-over point, respectively, as recommended by Pappas and Woodside (2021).

In this research, percentile values corresponding to the benchmark anchor points of 0.95, 0.5, and 0.05 are determined using IBM SPSS software package. After the calibration of the dataset, a fuzzy dataset with values between 0 and 0.9 is obtained (block diagram stage 5). Percentile values for benchmark anchor points are given in Appendix Table A.4, and the calibrated dataset is given at Appendix Table A.5.

At this stage, the fsQCA software is used to find a truth table providing combinations of digital platforms attributes driving platform infrastructuring (block diagram stage 6). For this analysis, fsQCA 4.0 software from Compass Inc.[4] is employed. This truth table, shown in Table 2, depicts each combination of digital platform attributes that results in infrastructuring of digital platforms. Initially, 2^k (where k is the number of variables in the dataset) different combinations are obtained. These combinations are subsequently optimized using a frequency cutoff value. To optimize, the "option" command in the fsQCA software is exercised, resulting in only those combinations of platform attributes that provide solutions above the cutoff value.

In this research, a cutoff value of 1 has been applied in the fsQCA software, as recommended by Pappas and Woodside (2021). The truth table results, representing configurations of digital platform attributes driving infrastructuring, are analyzed in terms of two fsQCA benchmarks: consistency and coverage. Consistency expresses the degree of approximation to results, similar to the significance level in conventional quantitative analysis (Park & Mithas, 2020). Coverage specifies the extent to which the outcome is explained by that combination of platform attributes, akin to the R^2 value in conventional quantitative methods (Ragin, 1987).

The benchmark values of consistency (0.8) and coverage (0.9) have been defined by Pappas and Woodside (2021) and have been used in this research. However, in this research, all values obtained in the first iteration of results are above the benchmark values.

Table 2. Truth Table

Modularity	Opemess	Generativity	Scalability	Hetrg	Criticality	Ubiquity	Number of Cases	Degree of Infra	Raw Consist.	PRI Consist.	SYM Consist.
0	0	0	0	0	1	1	9	1	0.9815	0.9813	0.9565
0	0	1	0	0	1	1	6	1	0.9857	0.9844	0.9875
0	1	1	1	1	1	1	4	1	0.9543	0.9539	0.9419
0	0	0	0	0	0	0	1	0	0.7051	0.1788	0.1911
0	0	0	0	0	0	1	1	1	0.5477	0.5455	0.5156

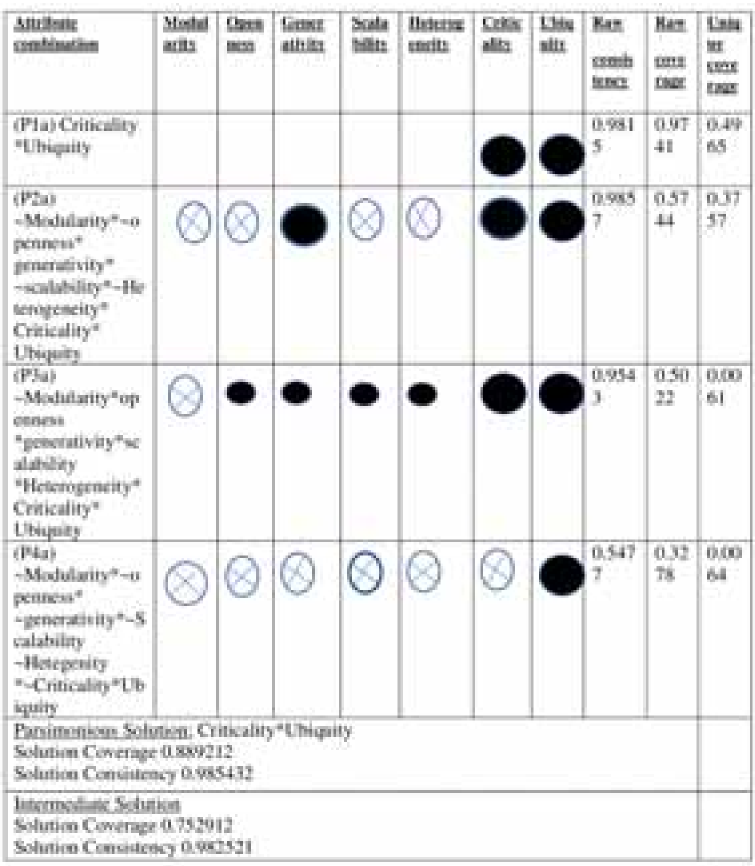
RESULTS

In the top three rows of the truth table (see Table 2), raw consistency is above the threshold value (0.80). However, the bottom two rows have raw consistency values lower than the threshold value. Similarly, PRI consistency is above the threshold value (0.50) and is very close to raw consistency, except for ‘all zero’ solutions appearing in the fourth row, which makes it an outlier solution.

The first case is a solution with nine cases having a combination of criticality and ubiquity attributes. The second case is a solution with six cases in which the generativity attribute combines with the criticality and ubiquity attributes. The next solution, comprising four cases, has all the attributes present except modularity. Subsequent solutions with all attribute values as 0 are not relevant. The bottommost two solutions have raw consistency values below the benchmark value of 0.80. Hence, these two solutions do not result in infrastructuring. Therefore, if the degree of infrastructure is zero or the number of cases is less than or equal to 1, the configuration is not a candidate solution driving infrastructuring. These results need to be further checked using standard analysis to obtain parsimonious and intermediate solutions (see Figure 2).

After standard analysis, four configurations are obtained, as shown diagrammatically in Figure 2. Each solution, in its respective row, shows a set of combinations that result in a desired output, namely, digital platforms with infrastructure-like characteristics. In the diagram, black circles indicate the presence of a condition, while circles with an X indicate the absence of a condition. A larger

Figure 2. Standard Analysis



Attribute combination	Modularity	Openness	Generativity	Scalability	Heterogeneity	Criticality	Ubiquity	Raw consistency	Raw coverage	Unique coverage
(P1a) Criticality *Ubiquity						●	●	0.9815	0.9741	0.4965
(P2a) ~Modularity*~openness* generativity* ~scalability*~Heterogeneity* Criticality* Ubiquity	⊗	⊗	●	⊗	⊗	●	●	0.9857	0.5744	0.3757
(P3a) ~Modularity*openness *generativity*scalability *Heterogeneity* Criticality* Ubiquity	⊗	●	●	●	●	●	●	0.9543	0.5022	0.0061
(P4a) ~Modularity*~openness* ~generativity*~Scalability ~Hetepenity *~Criticality*Ubiquity	⊗	⊗	⊗	⊗	⊗	⊗	●	0.5477	0.3278	0.0064
Parsimonious Solution: Criticality*Ubiquity Solution Coverage 0.889212 Solution Consistency 0.985432										
Intermediate Solution Solution Coverage 0.752912 Solution Consistency 0.982521										

black circle indicates a core condition, which has a strong causal relation with the outcome, while a smaller black circle indicates a peripheral condition. Blanks represent the "don't care" condition.

A parsimonious solution represents core conditions that cannot be omitted from any combination of attributes (Pappas & Woodside, 2021). This configuration comprises a minimum number of elements that still bring out the outcome of interest. On the other hand, the intermediate solution includes both core and peripheral conditions. The results obtained after this analysis represent sufficient conditions for infrastructuring.

DISCUSSION

The results of the standard analysis indicate four configurations of digital platform attributes that drive infrastructuring (P1a, P2a, P3a, and P4a, shown in Figure 2). This section first analyzes the parsimonious and intermediate solutions, and then makes four key observations based on this analysis.

Among the solutions, P1a (a configuration of criticality and ubiquity) has the highest raw coverage (0.9741). This implies that a combination of criticality and ubiquity attributes is empirically the most relevant configuration for driving the infrastructuring of digital platforms. The unique coverage for this solution is also very high at 0.4965, which indicates that this configuration covers approximately 49% of cases independently. As a parsimonious solution, its overall solution coverage is 0.8892, with a high solution consistency of 0.9854 (higher than the threshold value of 0.80). Thus, it can be inferred that the characteristics of criticality and ubiquity, working as a combinational configuration, best drive the infrastructuring of digital platforms and cannot be excluded from any solution.

Next is solution P2a, which includes the attributes of criticality, ubiquity, and generativity. This solution has a raw coverage of 0.5744 and a unique coverage of 0.3757. This solution's consistency value is also high at 0.9825 (above the threshold value of 0.80). P2a represents the intermediate solution, with a raw consistency value marginally higher (0.9857) than that of the parsimonious solution (0.9815), consistent with benchmark values given by Pappas and Woodside (2021). Both the parsimonious and intermediate solutions have criticality and ubiquity attributes.

This leads to the first key observation: criticality, ubiquity, and generativity features (represented by the first two configurations, P1a and P2a of Figure 2) are essential for the infrastructuring of digital platforms. Moving on to the two remaining configurations (P3a and P4a), their unique coverage is very low (0.006) and is below the threshold value of 0.80. Hence, the second key observation is that solutions having attributes of modularity and heterogeneity overlap or are subsumed within the parsimonious and intermediate solutions.

Thus, this research reveals that only criticality, ubiquity, and, to a lesser extent, generativity, when working in configuration, provide sufficient conditions for infrastructuring. This result is consistent with earlier findings by Verdecchia et al. (2022), who discovered that ease of integration is a critical adoption factor, corresponding directly to the generativity attribute discovered in this research. This gives rise to the study's third key observation: attributes contributing to infrastructuring also aid the adoption process of such artifact.

While each of the abovementioned parsimonious and intermediate configurations are a sufficient condition in itself, it is also recommended to examine the necessary conditions for each of the single variables. The results of single necessary conditions, along with explanatory notes, appear in the appendix (see Table A.6). The necessary conditions, as obtained from the fsQCA, also confirm that criticality, ubiquity, and generativity are key attributes of the infrastructuring of digital platforms. This leads to the fourth key observation: the attributes of criticality, ubiquity, and generativity are both necessary and sufficient to drive the infrastructuring of digital platforms.

As recommended by several authors (Pappas & Woodside, 2021; Ragin, 2008), the results and interpretations of fsQCA need to be further substantiated qualitatively using descriptive cross-analysis with contextual knowledge and the extant research literature. Rubinson et al. (2019) observed that in fsQCA, causation is established through substantive knowledge and not only through empirical metrics alone. For qualitative analysis, representative social media digital platforms were used as sample cases to validate the fsQCA findings and gain additional insights. Such evaluation is possible because reliable data regarding the use of social media digital platforms are published regularly[5] and available in the public domain.

Qualitative Analysis

The ubiquity attribute of a system can be approximated by the usage quotient, which represents the number of users of a particular digital platform divided by the total number of internet users (Hanseth & Lyytinen, 2016). As shown in Table 3, digital platforms with high user quotients display infrastructure characteristics. In addition, social media digital platforms with infrastructural qualities, such as Google and Facebook, have users dispersed across the globe (e.g., 85% of the population in the United State and Europe, 80% in South America, 55% in Africa, 34% in South Asia, and 66% in Australia use such digital platforms), making them highly ubiquitous.

Another indicator of ubiquity is manifoldness, which refers to the type of activities that can be performed using a digital platform. Manifoldness can be represented as different types of activities that can be carried out digitally using such platforms. For instance, data presented in Table 3 for Facebook, one of the most popular platforms, illustrate its extensive use in almost all digital activities in society. Notably, digital platforms with high user quotients have high manifoldness as well.

Hence, digital platforms are ubiquitous across both parameters: extensive usage (represented by the usage quotient and global geographical spread of the user base) and manifoldness in activities they enable. Similarly, the criticality attribute can be qualitatively described by considering the number of active users globally who would be affected by disruptions to these digital platforms. As shown in Table 3, if such platforms are disrupted completely or in part, a substantial portion (more than one-third) of the global population would be adversely affected, underscoring the critical nature of such platforms.[6]

Finally, the generativity attribute can also be qualitatively analyzed. Social media digital platforms are generative owing to the large number of boundary resources, APIs, software development kits (SDK), and code libraries provided by platform owners to software developers for creating complementary applications. The generativity capability can be measured by the number and type of boundary resources offered by any platform. The results are shown in Table 3, indicating a large variety of APIs provided as digital platform boundary resources. APIs are a significant source of generativity. For example, Google Maps has evolved into infrastructure by combining with millions

Table 3. Qualitative Analysis

Digital Platform	Ubiquity		Criticality (Number of Users of Platform/Global Population)	Generativity (Number of APIs Available to Developers)
	Usage Quotient (Number of Users of a Platform/Total Number of Internet Users)	Embeddedness/Manifoldness (Different Types of Activities That Can Be Carried Out Digitally Using Such Digital Platforms)		
Facebook	51% (2.5 bn/4.9 bn)	Marketing by influencers (23%), education (15%), sports (27%), nonprofit (10%) and hospitality (10%)[7].	37% (2.96 bn users/7.96 bn global population)	13 different types of APIs [8]
YouTube	37%		32% (2.6 bn/7.96 bn)	15[9]
WhatsApp	28%		25% (2 bn/7.96 bn)	5 types of API [10]
Quora	4%		2% (0.2 bn/7.96 bn)	

of other hardware components (automobiles, tablets, and cell phones), applications (navigation and defense), and usage (street view and satellite view). Today, Google Maps is a de facto global standard for geospatial web and geolocation services, representing a critical digital infrastructure (Plantin & Punathembekar, 2019).

Solution P2a (see Figure 2) shows that attributes like modularity, scalability, openness, and heterogeneity are not sufficient for driving the infrastructuring of digital platforms. This qualitative assessment corroborates this fact that the core architecture of popular digital platforms is not necessarily modular. Instead, in several cases, it tends to be monolithic. For instance, Facebook is a single 20-million-line application at its core, while Google has assembled a single codebase consisting of 2 billion lines of code using 85 terabytes of memory (Tiwana, 2015).

Similarly, regarding the openness attribute, very few popular social media digital platforms follow true open standards. Most of these systems follow platform-specific policies and proprietary standards. Despite the lack of modularity and openness attributes, platforms like Facebook and WeChat have been widely regarded as having undergone a transformation into digital infrastructure (Plantin & De Seta, 2019). This leads to the study's fifth key observation: attributes such as modularity, scalability, openness, and heterogeneity, acting alone or in a configuration, are insufficient for driving the infrastructuring process in digital platforms.

RESEARCH IMPLICATIONS AND CONTRIBUTIONS

Conceptual Contribution

Several well-known IS researchers (Constantinides et al., 2018; De Reuver et al., 2019) have put forth future IS research agenda, one of which includes an examination of the popular phenomenon of infrastructuring of digital platforms. This research is an answer to such research recommendations. By employing a systematic approach grounded in the set theory-oriented configurational analysis, this research provides a suitable conceptual tool for examining complex artifacts like digital platforms, characterized by mutually interdependent components. Moreover, this quantitative approach based on set theory does away with the need for linear dependence, exogeneity, homoskedasticity, non-collinearity, and other criteria outlined in the Gauss Markov framework. Set theory-based configurational research has been held as a superior conceptual approach for analyzing such social science research problems (Fiss et al., 2013).

Contribution to Digital Platform Literature

In extant IS research literature, with some exceptions, majority of digital platform research has been largely based on qualitative methods (Helmond et al., 2019; Sorenson, 2017). This research is one of the first to address the infrastructuring phenomenon both quantitively and qualitatively. Rather than adhering to the qualitative-quantitative binary, this research combines both case-based qualitative analysis with fsQCA based quantitative research. This approach not only contributes but also enriches extant literature on digital platforms.

Contribution to e-Adoption Research Literature

This research contributes significantly to e-adoption research literature. The process of infrastructuring of digital platforms leads to increased adoption and usage of such IT artefacts within society. By identifying the attributes of digital platforms that contribute to infrastructuring, this study highlights factors that enhance e-adoption and usage of such platforms.

Methodological Contribution

It has been stated that research methods and theory co-evolve to generate theory (Sorenson, 2017). Based on this premise, this research makes a methodological contribution using fsQCA to examine digital identity platforms. This unique methodological approach creates a nuanced understanding of digital platform infrastructuring characteristics through fuzzy logic and set theory-based configurational analysis. This application is a methodological contribution to digital platform research, as it has not been applied previously to study digital platforms.

Contribution for Business Managers and Practitioners

This research can serve as a valuable resource for business managers and practitioners as it identifies the attributes of business-oriented digital platforms that drive infrastructuring, leading to higher revenue and greater market share. This understanding will help business managers enhance their platform-business design and operations, ultimately maximizing revenue, which is the primary aim of infrastructuring business-oriented digital platforms (Helmond et al., 2019).

Theoretical Contribution Specifically Attributable to This Research

In addition to contributing to conceptual, methodological, e-adoption, and digital platform literature, as outlined before, this research makes a specific contribution in the theoretical domain by integrating and validating two distinct infrastructure research paradigms (complexity and network relational) in infrastructural studies. This integrated approach has not been previously explored. Specifically, this research applies two different theories related to infrastructural studies: the complexity paradigm (theory of LTS) and the relational network perspective (theory of network criticality) to determine candidate attributes of infrastructuring in digital platforms. Accordingly, this study extends the application of complexity and relational network perspectives within infrastructural studies to the context of popular digital platforms.

LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

One limitation of this research is the relatively small dataset available for the application of fsQCA. This is primarily due to the incipient nature of the research topic and the challenges associated with collecting data on digital platform design, which is often shrouded in secrecy. Nonetheless, despite these constraints, there is adequate secondary design data in the public domain that meet the requirements for the application of fsQCA. In fact, the database size in this research exceeds the benchmark database size recommended by Pappas and Woodside (2021). To address this limitation, future research could be expanded to include more digital platforms from other business domains, enabling a more comprehensive cross-case analysis.

The second limitation concerns the accuracy and precision of the results from fsQCA. To compensate for this limitation, a separate qualitative analysis was carried out to cross-evaluate the fsQCA results. However, this limitation presents a future research opportunity. Quantitative research based on second-generation quantitative analysis methods, such as structured equation modeling, can be carried out to compare and refine the results obtained from fsQCA, thereby improving the accuracy and exactness of the research.

REFERENCES

Abbott, R. (2007). Putting complex systems to work. *Complexity*, *13*(2), 30–49. doi:10.1002/cplx.20200

Andrade, R., Arego, B., Oliveira, P., Maia, E., Viana, W., & Nogueira, T. (2021). Multifaceted infrastructure for self-adaptive IoT systems. *Information and Software Technology*, *132*, 132–156. doi:10.1016/j.infsof.2020.106505

Beverungen, D., Hess, T., Köster, A., & Lehrer, C. (2022). From private digital platforms to public data spaces: Implications for the digital transformation. *Electronic Markets*, *32*(2), 493–501. doi:10.1007/s12525-022-00553-z

Bonina, C., Koskinen, K., Eaton, B., & Gawer, A. (2021). Digital platforms for development: Foundations and research agenda. *Information Systems Journal*, *31*(6), 869–902. doi:10.1111/isj.12326

Bowker, G. C., & Star, S. L. (1999). *Sorting things out: Classification and its consequences*. MIT Press.

Busch, C. (2022). Regulating the expanding content moderation universe: A European perspective on infrastructure moderation. *UCLA JL & Tech.*, *27*, 32.

Chester, M. V., & Allenby, B. (2019). Toward adaptive infrastructure: Flexibility and agility in a non-stationarity age. *Sustainable and Resilient Infrastructure*, *4*(4), 173–191. doi:10.1080/23789689.2017.1416846

Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Introduction—Platforms and Infrastructures in the digital age. *Information Systems Research*, *29*(2), 381–400. doi:10.1287/isre.2018.0794

Dawson, R. (2013). *Bridges n'that: An infrastructure definition for iBUILD*. Newcastle University.

De Reuver, M., Sørensen, C., & Basole, R. C. (2018). The digital platform: A research agenda. *Journal of Information Technology*, *33*(2), 124–135. doi:10.1057/s41265-016-0033-3

Edwards, P. N. (2003). Infrastructure and modernity: Force, time, and social organization in the history of sociotechnical systems. *Modernity and Technology*, *1*, 185–226.

Evans, P. C., & Basole, R. C. (2016). Revealing the API ecosystem and enterprise strategy via visual analytics. *Communications of the ACM, 59*(2,) 26–28.

Ferber, J., & Weiss, G. (1999). *Multi-agent systems: An introduction to distributed artificial intelligence* (Vol. 1). Addison-Wesley.

Fiss, P. C. (2007). A set-theoretic approach to organizational configurations. *Academy of Management Review*, *32*(4), 1180–1198. doi:10.5465/amr.2007.26586092

Fiss, P. C., Marx, A., & Cambré, B. (2013). Configurational theory and methods in organizational research: Introduction. In *Configurational theory and methods in organizational research* (Vol. 38, pp. 1–22). Emerald Group Publishing Limited. doi:10.1108/S0733-558X(2013)0000038005

Gehl, R., & McKelvey, F. (2019). Bugging out: Darknets as parasites of large-scale media objects. *Media Culture & Society*, *41*(2), 219–235. doi:10.1177/0163443718818379

George, A. L., & Bennett, A. (2005). *Case studies and theory development in the social sciences*. MIT Press.

Glaesser, J. (2021). Exploring the issue of asymmetry in analysing educational poverty using qualitative comparative analysis (QCA). *Methodological Innovations*, *14*(2), 20597991211040062. doi:10.1177/20597991211040062

Grant, C., & Osanloo, A. (2014). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house." *Administrative Issues Journal, 4*(2), 4.

Greckhamer, T., Furnari, S., Fiss, P. C., & Aguilera, R. V. (2018). Studying configurations with qualitative comparative analysis: Best practices in strategy and organization research. *Strategic Organization*, *16*(4), 482–495. doi:10.1177/1476127018786487

Greenstein, S. (2021). *Digital infrastructure. Economics of infrastructure investment*. University of Chicago Press.

Hanseth, O., & Lyytinen, K. (2016). Design theory for dynamic complexity in information infrastructures: The case of building internet. *Journal of Information Technology*, *25*(1), 1–19. doi:10.1057/jit.2009.19

Hanseth, O., & Monteiro, E. (1997). Inscribing behaviour in information infrastructure standards. *Accounting Management and Information Technologies*, *7*(4), 183–211. doi:10.1016/S0959-8022(97)00008-8

Hein, A., Schreieck, M., Riasanow, T., Setzke, D. S., Wiesche, M., Böhm, M., & Krcmar, H. (2020). Digital platform ecosystems. *Electronic Markets*, *30*(1), 87–98. doi:10.1007/s12525-019-00377-4

Helmond, A., Nieborg, D. B., & van der Vlist, F. N. (2019). Facebook's evolution: Development of a platform-as-infrastructure. *Internet Histories*, *3*(2), 123–146. doi:10.1080/24701475.2019.1593667

Henfridsson, O., & Bygstad, B. (2013). The generative mechanisms of digital infrastructure evolution. *Management Information Systems Quarterly*, *37*(3), 907–931. doi:10.25300/MISQ/2013/37.3.11

Henningsson, S., & Eaton, B. D. (2023). Governmental regulation and digital infrastructure innovation: The mediating role of modular architecture. *Journal of Information Technology*, *38*(2), 126–143. doi:10.1177/02683962221114429

Holland, J. H. (2014). *Complexity: A very short introduction*. OUP Oxford. doi:10.1093/actrade/9780199662548.001.0001

Hughes, T. P. (1987). The evolution of large technological systems. In *The social construction of technological systems: New directions in the sociology and history of technology* (pp. 51–82). MIT Press.

Jiang, H., & Murmann, J. P. (2022). The rise of China's digital economy: An overview. *Management and Organization Review*, *18*(4), 790–802. doi:10.1017/mor.2022.32

Joglekar, N., Anderson, E. G. Jr, Lee, K., Parker, G., Settanni, E., & Srai, J. S. (2022). Configuration of digital and physical infrastructure platforms: Private and public perspectives. *Production and Operations Management*, *31*(12), 4515–4528. doi:10.1111/poms.13865

Kazan, E., Tan, C., Lim, E., Sorenson, C., & Damsgaard, J. (2018). Disentangling digital platform competition: The case of UK mobile payment platforms. *Journal of Management Information Systems*, *35*(1), 180–219. doi:10.1080/07421222.2018.1440772

Kenney, M., & Zysman, J. (2019). Work and value creation in the platform economy. In *Work and labor in the digital age* (Vol. 33, pp. 13–41). Emerald Publishing Limited.

Mayntz, R., & Hughes, T. (2019). *The development of large technical systems*. Routledge. doi:10.4324/9780429309991

Mukherjee, R. (2019). Jio sparks Disruption 2.0: Infrastructural imaginaries and platform ecosystems in digital India. *Media Culture & Society*, *41*(2), 175–195. doi:10.1177/0163443718818383

Mukhopadhyay, S., Bouwman, H., & Jaiswal, M. P. (2019). An open platform centric approach for scalable government service delivery to the poor: The Aadhaar case. *Government Information Quarterly*, *36*(3), 437–448. doi:10.1016/j.giq.2019.05.001

Nubel, K., Bühler, M. M., & Jelinek, T. (2021). Federated digital platforms: Value chain integration for sustainable infrastructure planning and delivery. *Sustainability (Basel)*, *13*(16), 8996. doi:10.3390/su13168996

Ordanini, A., Parasuraman, A., & Rubera, G. (2014). When the recipe is more important than the ingredients: A qualitative comparative analysis (QCA) of service innovation configurations. *Journal of Service Research*, *17*(2), 134–149. doi:10.1177/1094670513513337

Palmer, M., Toral, I., Truong, Y., & Lowe, F. (2022). Institutional pioneers and articulation work in digital platform infrastructure-building. *Journal of Business Research*, *142*, 930–945. doi:10.1016/j.jbusres.2021.12.067

Pappas, I. O., & Woodside, A. G. (2021). Fuzzy-set qualitative comparative analysis (fsQCA): Guidelines for research practice in information systems and marketing. *International Journal of Information Management*, *58*, 102310. doi:10.1016/j.ijinfomgt.2021.102310

Park, Y., & Mithas, S. (2020). Organized complexity of digital business strategy: A configurational perspective. *Management Information Systems Quarterly*, *44*(1), 85–127. doi:10.25300/MISQ/2020/14477

Pierson, J. (2021). Digital platforms as entangled infrastructures: Addressing public values and trust in messaging apps. *European Journal of Communication*, *36*(4), 349–361. doi:10.1177/02673231211028374

Plantin, J. C., & De Seta, G. (2019). WeChat as infrastructure: The techno-nationalist shaping of Chinese digital platforms. *Chinese Journal of Communication*, *12*(3), 257–273. doi:10.1080/17544750.2019.1572633

Plantin, J. C., Lagoze, C., Edwards, P. N., & Sandvig, C. (2018). Infrastructure studies meet platform studies in the age of Google and Facebook. *New Media & Society*, *20*(1), 293–310. doi:10.1177/1461444816661553

Plantin, J. C., & Punathambekar, A. (2019). Digital media infrastructures: Pipes, platforms, and politics. *Media Culture & Society*, *41*(2), 163–174. doi:10.1177/0163443718818376

Raghavan, V., Jain, S., & Varma, P. (2019). India stack: Digital infrastructure as public good. *Communications of the ACM*, *62*(11), 76–81. doi:10.1145/3355625

Ragin, C. C. (1987). *The comparative method. Moving beyond qualitative and quantitative strategies*. University of California Press.

Ragin, C. C. (2008). *Redesigning social inquiry: Fuzzy sets and beyond*. University of Chicago Press. doi:10.7208/chicago/9780226702797.001.0001

Rubinson, C. (2019). Contradictions in fsQCA. *Quality & Quantity*, *47*(5), 2847–2867. doi:10.1007/s11135-012-9694-3

Sanchez, R., & Mahoney, J. T. (1996). Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management Journal*, *17*(S2), 63–76. doi:10.1002/smj.4250171107

Sarangi, A. K., & Pradhan, R. P. (2020). ICT infrastructure and economic growth: A critical assessment and some policy implications. *Decision (Washington, D.C.)*, *47*, 363–383.

Scholl, H. J., & Patin, B. J. (2014). Resilient information infrastructures: Criticality and role in responding to catastrophic incidents. *Transforming Government: People*, *Process and Policy*, *8*(1), 28–48.

Sørensen, C. (2017). *Digital platform and infrastructure innovation*. Mobile Strategy Challenges.

Spagnoletti, P., Resca, A., & Lee, G. (2015). A design theory for digital platforms supporting online communities: A multiple case study. *Journal of Information Technology*, *30*(4), 364–380. doi:10.1057/jit.2014.37

Sriramdas, V., Chaturvedi, S. K., & Gargama, H. (2014). Fuzzy arithmetic-based reliability allocation approach during early design and development. *Expert Systems with Applications*, *41*(7), 3444–3449. doi:10.1016/j.eswa.2013.10.048

Star, S. L., & Ruhleder, K. (1996). Steps toward an ecology of infrastructure: Design and access for large information spaces. *Information Systems Research*, *7*(1), 111–134. doi:10.1287/isre.7.1.111

Stehlin, J. G., & Payne, W. B. (2022). Mesoscale infrastructures and uneven development: Bicycle sharing systems in the United States as "already splintered" urbanism. *Annals of the American Association of Geographers*, *112*(4), 1065–1083. doi:10.1080/24694452.2021.1956874

Tan, B., Pan, S. L., Lu, X., & Huang, L. (2015). The role of IS capabilities in the development of multi-sided platforms: The digital ecosystem strategy of Alibaba.com. *Journal of the Association for Information Systems*, *16*(4), 248–280. doi:10.17705/1jais.00393

Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Digital infrastructures: The missing IS research agenda. *Information Systems Research*, *21*(4), 748–759. doi:10.1287/isre.1100.0318

Tiwana, A. (2015). Evolutionary competition in platform ecosystems. *Information Systems Research*, *26*(2), 266–281. doi:10.1287/isre.2015.0573

Van der Vleuten, E. (2009). Large technical systems. *A Companion to the Philosophy of Technology*.

Verdecchia, R., Lago, P., & de Vries, C. (2022). The future of sustainable digital infrastructures: A landscape of solutions, adoption factors, impediments, open problems, and scenarios. *Sustainable Computing : Informatics and Systems*, *35*, 100767. doi:10.1016/j.suscom.2022.100767

Walsham, G., & Sahay, S. (2006). Research on information systems in developing countries: Current landscape and future prospects. *Information Technology for Development*, *12*(1), 7–24. doi:10.1002/itdj.20020

Yoo, Y., Boland, R. J. Jr, Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science*, *23*(5), 1398–1408. doi:10.1287/orsc.1120.0771

Zhou, A. (2022). Digital infrastructure and economic growth—Evidence for China. *Journal of Infrastructure. Policy and Development*, *6*(1), 1397.

ENDNOTES

[1] https://downdetector.com/status/facebook/news/414877-problems-at-facebook
[2] www.bloomberg.com/news/articles/2021-10-04/zuckerberg-loses-7-billion-in-hours-as-facebook-plunges
[3] www.statista.com/statistics
[4] www.compasss.org/software
[5] www.statista.com; www.datereportal.com; www.earthweb.com
[6] https://www.internetworldstats.com/stats.htm
[7] https://influencermarketinghub.com/social-media-marketing-benchmark-report/
[8] https://developers.facebook.com/docs/
[9] https://developers.google.com/youtube/v3/getting-started
[10] https://developers.facebook.com/docs/whatsapp/; https://www.interakt.shop/resource-center

APPENDIX

Table A1. Details of Coders

Expert	Designation	Years of Experience		Area of Responsibility	Prior Understanding of Computer Assisted Qualitative Content Analysis Software	Number of Hours Spent With Authors	Weightage
		Digital Platform Design	Digital Platform Operations				
Expert 1	Project Manager	2	10	Digital Platform operations	yes	60 hours over 30 day	0.45
Expert 2	Developer	Nil	7	API designer	No	40 hours over 30 days	0.30
Expert 3	Sales manager	Nil	Nil	Sales and liaison	No	30 hours over 30 days	0.25

Table A2. Dataset as quantitative indices after Trapezoidal Fuzzy Arithmetic

Name of Platform	Modularity	Openness	Generativity	Scalability	Heterogeneity	Criticality	Ubiquity	Infra
Facebook	6	3.6	7.4	8.5	5.4	6	5.6	7.5
Google	4	3.6	7.4	8.5	7.6	7.4	7.4	7.7
Openweb	6.5	8.5	8	8.5	7.9	7.4	7.4	8.1
Wechat	4.5	3.6	5.4	5.4	7.6	5.9	5.6	5.6
Alibaba	4.5	3.6	5.4	6	5.6	6	5.6	6.9
Uber	5.6	3.6	5.4	5.6	4.7	6	5.9	5.2
AirBnB	5	5	5.4	5.6	4.7	5.4	5.6	5.1
Android	7.4	8	8	8.5	6.7	7.1	8.5	7.9
AppleIOS	7.4	5.6	7.6	7.6	7.1	6.5	6	7.1
Firefox	7.9	7.9	7.9	5.6	7.1	4.5	6.7	6.2
Suomi	7.4	7.4	4.425	4.5	5.4	4.5	5.6	5.4
Microsoft	8	5.6	7.6	5.6	5.6	6.5	5.4	6.1
Pingit	6.5	4.5	5.4	3.5	3.6	4.5	3.6	4.3
Blockchain	6.025	8.025	5.325	5.925	5.025	4.425	3.825	5.1
Internet	6.025	8.325	7.725	8.925	8.925	8.925	9.825	8.8
Ethernet	6.025	8.325	5.025	7.425	5.025	7.425	7.425	7.9
UPI	7.9	8	7.6	8.5	7	7.1	5.6	7.2
Amazon	7.4	5.6	6	7.6	6.5	5.4	5.6	6.1
Flipkart	7.725	5.925	6.225	5.925	6.825	4.725	4.725	6.3
WhatsApp	7.715	5.275	6.175	7.175	5.175	4.725	5.275	7.5
Twitter	7	5.1	5.6	7.6	5.3	5.675	4.5	5.9

Table A3. Result of Reliability and Validity of Variables (Cronbach alfa and Kendall Tau Correlation Test Results)

Case Processing Summary				Reliability Statistics			
		N	%				
Cases	Valid	20	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items			N of Items
	Excluded	1	.846	.854			7
	Total	21	100.0				
Correlations for all pairs of data series (method=kendall)							
	Modu	Open	Gener	Scal	Het	Crti	Ubi	Deg
Mod	1	0.694	0.153	0.062	0.065	-0.01	0.041	0.222
Open	0.694	1	0.298	0.239	0.221	0.107	0.236	0.382
Gener	0.153	0.298	1	0.472	0.505	0.382	0.345	0.01
Scal	0.062	0.239	0.472	1	0.419	0.545	0.396	0.056
Het	0.065	0.221	0.505	0.419	1	0.372	0.448	0.218
Crti	-0.01	0.107	0.382	0.545	0.372	1	0.606	0.338
Ubi	0.041	0.236	0.345	0.396	0.448	0.606	1	0.414
Deg	0.222	0.382	0.01	0.056	0.218	0.338	0.414	1

Table A4. Percentile Values for Calibration Using IBM SPSS

		Modularity (M)	Openness	Generativity	Scalability	Heterogeneity	Criticality	Ubiquity
N	Valid	20	20	20	20	20	20	20
	Missing	1	1	1	1	1	1	1
Percentiles	5	3.5175	2.4	3.7699	2.64	2.755	3.2312	2.534
	50	6.4721	4.3	5.1465	6.1832	4.53	5.	4.759
	95	7.7645	7.3176	7.00	7.7231	7.55	7.1476	7.77231

Table A5. Dataset After Calibration

Name of Digital Platform	Modularity	Openness	Generativity	Scalability	Heterogeneity	Criticality	Ubiquity	Degree of Infrastructuring
Facebook	0.8	0.8	0.89	0.95	0.85	0.8	0.95	0.8
Google	0.8	0.75	0.89	0.95	0.89	0.79	0.87	0.83
Openweb	0.8	0.97	0.95	0.95	0.92	0.79	0.87	1
Wechat	0.8	0.9	0.75	0.81	0.89	0.82	0.85	0.8
Alibaba	0.75	0.8	0.75	0.27	0.7	0.7	0.7	0.73
Uber	0.7	0.78	0.9	0.8	0.76	0.77	0.88	0.86
AirBnB	0.12	0.5	0.29	0.2	0.17	0.21	0.5	0.43
Android	0.77	0.95	0.95	0.95	0.77	0.71	0.95	0.72
Apple IOS	0.77	0.65	0.92	0.77	0.83	0.5	0.6	0.62
Firefox	0.94	0.95	0.95	0.6	0.83	0.28	0.76	0.72
Suomi	0.77	0.92	0.89	0.6	0.65	0.68	0.7	0.99
Microsoft	0.95	0.65	0.92	0.2	0.52	0.5	0.42	0.62
Pingit	0.38	0.32	0.29	0.03	0.02	0.08	0.04	0.01
Blockchain	0.96	0.95	0.27	0.25	0.28	0.08	0.06	0.34
Internet	0.96	0.97	0.93	0.98	0.97	0.97	0.97	1
Ethernet	0.96	0.97	0.86	0.87	0.28	0.8	0.87	1
UPI	0.94	0.95	0.92	0.95	0.82	0.71	0.9	1
Amazon	0.77	0.65	0.5	0.77	0.73	0.21	0.5	0.73
Flipkart	0.9	0.72	0.58	0.25	0.79	0.11	0.2	0.46
Whatsapp	0.63	0.57	0.57	0.59	0.34	0.27	0.37	0.16
Twitter	0.5	0.52	0.35	0.77	0.4	0.21	0.15	0.46

Table A6. Single Necessary Analysis Using fsQCA

Ser No	Attribute/Configuration	Consistency	Coverage
1	Modularity	0.507453	0.620033
2	Openness	0.740515	0.928632
3	Generativity	0.800813	0.898859
4	Scalability	0.750949	0.931751
5	Heterogeneity	0.808266	0.940852
6	Criticality	0.821138	0.982172
7	Ubiquity	0.851626	0.953666

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