Systematic Review

Delineating the Implications of Dispersing Teams and Teleworking in an Agile UK Construction Sector

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Abstract: A scientometric analysis of extant literature is conducted to elucidate upon the practicality of teleworking throughout industry as a prelude to prescribing a bespoke conceptual adoption model that embeds innovative digital technologies to facilitate teleworking for construction professionals. The model is premised upon the Royal Institute of British Architects (RIBA) work stages and illustrates how technologies are being used at each incremental stage. An interpretivist philosophy and inductive reasoning were adopted using a sample of longitudinal secondary data contained within pertinent extant literature, where each publication constitutes a unit of analysis. The qualitative scientometric software VOSviewer and Voyant Tools were utilised to examine emergent research trends, with further manual review of prominent papers contained within the sample dataset. Four distinct historical advances are delineated in a timeline that describes the evolution of home working from the 1970s through to the present day (and during the global COVID-19 pandemic). Key milestones delineated indicate how technological advances have created new opportunities for teleworking. The research indicates that an acceleration of digital advances has engendered modernity in contemporary work location patterns and that these offer potentials to reduce the environmental impact of anthropogenic activities. This unique study highlights how COVID-19 and available digital technologies have shaped the future of teleworking from home and the potential environmental impact of such. This concludes by signposting directions for future research into the adoption of teleworking at the organisational level and establishing the cost and environmental savings to businesses from abandoning the traditional model of employer-based working.

Keywords: teleworking; construction industry; scientometric analysis

1. Introduction

Since the term 'telecommuting' was first coined [1], the concept of teleworking has been considered and discussed from a variety of different perspectives and academic/industrial disciplines [2–5]. For example, organisational behaviour and social sciences researchers [6–10] consider teleworking from an intraorganisational and interpersonal perspective, detailing how work relationships and work/life balance is affected in teleworking scenarios. This research yields important findings that consider the beneficial and deleterious implications on the user. Similarly, research pertaining to implementation, fiscal considerations, and technological capability [11–14] consider the capability of contemporary technology [15] and how a changing industrial landscape could influence factors, including work location [12–14]. This aforementioned research utilised a meta-analysis highlighting limited cross-citation and overlap between various disciplines and authors who specialise in teleworking research. Consequently, when considering teleworking from

the perspective of a single industry, it is important to gather literature from various sources and apply it correctly within the specific research domain. Another factor to consider is that the well-espoused benefits may not apply to all teleworking users [10] and are often offset by factors, including disaffection, limited career progression, and social isolation [9,16–19].

Since 1971, the UK's population has increased by 16.27%, placing pressure on infrastructure, as the number of commuters has also increased by 29% [20,21], where, for example, 73.4% of workers in rural areas use motor vehicles to commute [22]. Ergo, it is imperative that viable solutions to reducing over-reliance on motorised vehicles for commuting are considered to reduce road traffic and concomitant pollution emissions [23,24]. Furthermore, technology has improved significantly over the last decade. This has been done to facilitate affordable teleworking, effectively removing barriers to widespread adoption [25]. Research also demonstrates that user preferences promote the increasing prevalence of teleworking, with many employees valuing flexible working arrangements [8,26]. Moreover, many teleworkers view increased flexibility as an employee retention tactic from employers [27]. Teleworking in 2020 is more relevant than ever. The COVID-19 pandemic led to 46.6% of people engaging in teleworking in April 2020 alone, 86% of whom reported that this was due to the global pandemic [28]. Commentators suggest that a 'new normal' of remote working has been established [29–32]. This radical transformation in working must also be considered against the backdrop of the environmental impact of increasing digital communication [33,34]. Dr Rabih Bashroush has conducted research exploring the impact of teleworking against factors such as: (i) a 40% increase in internet usage since the beginning of the COVID-19 pandemic; (ii) increased use of data centres and the subsequent increase in energy requirements facilitating teleworking (estimated 500,000 data centres in 2012 compared with 8,000,000 at the end of 2019); and (iii) the energy requirements of facilitating teleworking (a one-hour Zoom call at a 1 kWh consumption rate being equivalent to travelling 2 km by motor car or 10 km by train) [35]. The environmental impact of such energy consumption would be extensive if traditional fossil fuels are used to provide electricity; conversely, green energy would eliminate this impact. These factors have engendered the requirement for discussions regarding the practicalities of telecommuting and emphasised further factors for consideration alongside COVID-19, in particular discussing the practicalities of wide-scale adoption within specific industries such as the construction industry.

Construction projects are temporary organisations built upon collaboration and information exchange between numerous different supply chain companies, both within the industry (subcontractors, main contractors, employer consultants, etc.) and external to it (suppliers, agencies, local authorities) [36]. These relationships rely on efficient and effective information exchange and communication, particularly on large megaprojects [37]. Despite this, many traditional procurement arrangements have engendered adversarial relationships between the contractor and client [38,39], requiring a monumental shift toward more collaborative methods of project management to reduce conflict and facilitate project success [39,40]. Contemporary construction projects already provide a satellite office (site offices are a legal requirement), which could be expanded to facilitate teleworking for employees from different companies involved in a project and foster collaborative working environments.

Given the aforementioned contextualisation of the construction sector, this research aims to investigate teleworking in Industry 4.0 [41] and the global pandemic era. Research objectives are to: (i) conduct a meta-analysis on relevant secondary data contained in literature pertaining to teleworking; (ii) review pertinent findings and establish a consensus based upon the benefits and drawbacks of teleworking using a variety of literature sources; and (iii) investigate whether adoption of teleworking within the construction industry is practical.

2. Methodology

This research adopts inductive reasoning to study qualitative data, using publications as a unit of analysis, where each publication represents an item within the dataset. This dataset is subsequently analysed using an interpretivist approach and a two-step waterfall process [42–45]. First, a manual literature review is conducted [42,43] to: (i) establish key definitions; (ii) identify the practicalities of teleworking; and (iii) discuss the links between the construction industry and the habitual realities of teleworking and also explore the practicality of construction teleworking. Second, a scientometric analysis [46,47] using VOSviewer [48–50], and then with further analysis of prominent articles within the dataset using Voyant Tools [51–53], is utilised. Examining a much larger dataset (comprising relevant research papers published in English-language journals) to uncover research trends and identify future avenues for study. Conference papers were excluded from the analysis, as many conference papers are not subject to a rigorous peer-review process and lack scientific quality and integrity. Large quantities of data analysed using VOSviewer [54] illustrate interlinkages between articles and identify prominent terminologies used and how they describe findings. Various visualisations created identify cross-citation links, sources, authors, and geographical locations of publications. The research then highlights keywords using diagrams generated in Voyant Tools [51] to establish the prevailing academic discourse on teleworking. An overarching goal is to ascertain which areas of established knowledge on teleworking can be applied to construction industry workflows (from the habitual behaviour of employees who telework to the technology available to the modern construction professional), with a view to signposting future research direction.

VOSviewer visualises network data with individual nodes linked based upon a variety of possible fields (citation, keyword co-occurrence, geographical location and author, etc.), and the link strength is denoted by the proximity between nodes [48]. VOSviewer has been utilised to a plethora of topics ranging from contemporary trends in construction management technology [55] to mega-event orchestration such as the Formula One grand prix [56]. Researchers specifically note the capability of the technique to analyse large datasets. Using VOSviewer, Akinlolu et al. [55] were able to show, when analysing extant literature on construction health and safety, that Africa was substantially underrepresented in research and suggested this as an area for future research. Similarly, Chamberlain et al. [56] were able to demonstrate that a lack of knowledge regarding mega-event managers has hindered researchers' ability to 'learn lessons' from previous mega-events. Analysing a database sample of publications using the approach delineated will give significant insight into the wider research domain [57].

3. Defining Teleworking

A notable issue regarding 'teleworking' is the plethora of vague definitions or approaches adopted. Even within individual organisations, teleworking arrangements are not always like-for-like and do not necessarily suit every employee [9,10,16–19]. Complicating matters further, two employees with the same role within the same organisation may not perceive teleworking the same way. In simple terms, teleworking or telecommuting can be defined as working away from the employers' main campus (including working in a satellite office, home-based working, or mobile working) whilst supported by various technological solutions [58–62]. However, it often becomes difficult to establish who a specific definition applies to [6]. Definitions observed in the literature range from those who work three or more days a week from a location other than the employer's office [8] to "those who did most of their work at home or on the road, coming to the company's office for occasional meetings" (p. 154) [12]. It is theorised that teleworking falls into three main categories [26–62] and that these relate to not only 'home work' but also can encompass a variety of working arrangements; namely: (1) home-based teleworking; (2) satellite or client-based teleworking; and (3) mobile teleworking (Table 1). It is important to delineate and comprehend these definitions in order to engender a wider academic discourse.

Table 1. Definitions of teleworking.

	Definition	Description	Advantages	Disadvantages	References
1	Home-based Teleworking	Duties carried out in the employee's own home.	Reduction in work/life conflict; reduced commuting time; can increase job satisfaction; offering flexible working arrangements [with work from home options] can make jobs more attractive to applicants.	Sense of isolation from teams; potential role ambiguity, increased susceptibility to worry and anxiety; potential increase in working hours; cost of developing home office facilities.	[6–9,16,26,58,63]
2	Satellite or Client-based Teleworking	Duties are carried out away from the employer's main campus, but still in employer-controlled premises or at a client's premises.	Often a function of organisational needs and/or reduced commuting time.	No inherent benefit to work/life balance; employees can feel on the fringe of organisation; and distance from management.	[9,62,64]
3	Mobile Teleworking	Duties are carried out from no fixed location, often supported by mobile devices, for example field sales or repairs.	Intrinsic to role performance in some cases; high level of autonomy.	Relies on network availability; relies on substantial self-discipline. Does not promote work/life balance.	[62,64,65]

These definitions are all-encompassing to categorise working arrangements. This is beneficial for inventory purposes in research but limited in terms of comprehending the development of teleworking. For instance, mobile teleworking has always been prevalent in the construction industry because most 'site-based' workers work from a location away from their employer's base of operations. Whilst technology undeniably impacts their ability to carry out that role, it has not affected their work location—they have always worked away from their employer's main campus. Therefore, these definitions alone do not demonstrate how technology has expanded the workspace for those who were traditionally hamstrung by a lack of technology [25]. However, when technological developments are viewed longitudinally (from the 1970s to the present day), a generational pattern can be viewed as first, second, third, and fourth generations of teleworking. This model, in conjunction with information from other articles, has been expanded in Figure 1 and updated to include modern technological advancements such as cloud computing [66,67] and modern pressures such as COVID-19 [29,68].

Figure 1 depicts how teleworking has evolved with the advent of new Industry 4.0 technologies, particularly mobile technology, facilitating work in intermediate spaces and third spaces (e.g., for recreational or leisure purposes).
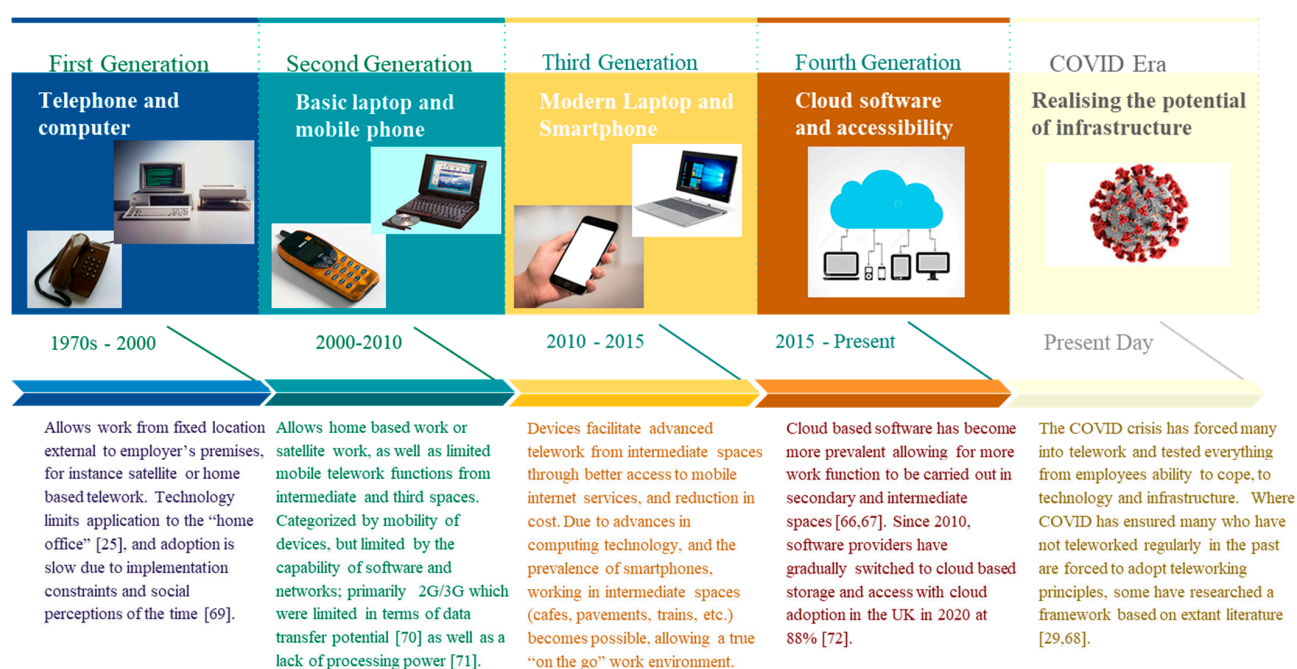
Figure 1. Definitions for the generational progression of enabling technology for teleworking [25,29,66–72].

Consequently, it is observed that technology has facilitated a new level of remote working, giving people access to organisational software and small handheld (yet computationally powerful) devices that they may traditionally have had to attend employer facilities to access. Industry-specific software (e.g., BIM360 for construction [73–75]) extends the work duties that can be carried out remotely. This increase in the availability of enabling technology has been reflected by increasing teleworking adoption. In 2020, 49% of US workers polled reported having telecommuted compared to just 9% in 1995, and 24% reported telecommuting more than 75% of the time [76]. Importantly, the COVID-19 global pandemic has forced the industry (which may not have considered teleworking previously) to adopt teleworking principles in their workplace [30,68].

Why Telework?

Employee perspectives are crucial when considering the impact of teleworking within an organisation. Factors including role performance, job satisfaction, work/life balance, technological enablement, and reduced commuting time have been demonstrated as key motivators for implementing teleworking within an organisation [8,25,26,64,77,78]. Fonner and Roloff [8] demonstrated that employees who telecommute can achieve reduced work/life conflict in comparison to employees who are office based, and a reduction in face-to-face contact with direct management does not impact capability or productivity. Furthermore, many employees favour a reduction in informal communication [8], as this tends to lead to a perceived focus on less frequent and quality of communication. Many employees are specifically attracted to roles that offer flexible working arrangements, and offering this can allow employers to be more competitive when recruiting [77]. This is supported by Anderson and Kelliher [7], who found that those surveyed viewed flexible working as an effort from their employer toward the retention of high-quality staff, finding that respondents had: (i) increased job satisfaction; (ii) felt less stressed; and (iii) had an increased sense of obligation toward their employers, which resulted in increased productivity. Furthermore, UK employees are also legally entitled to make an application for remote working, referred to as "making a statutory application" [79], and therefore, it can be in an employer's best interest that this can be facilitated.

Whilst extant literature demonstrates numerous key factors that drive people to telework, many studies reveal risks that require mitigation to achieve success when tele-

working. Morganson et al. [9] found that some respondents reported a feeling of isolation, where employees feel the effect of a lack of social contact. Morganson et al. (ibid) also observed that office-based workers reported a greater perceived work/life balance than those respondents who were home based and felt a sense of inclusion that was lacking in those who did not telework. This study (ibid) looked at a cross-sectional sample of employees from within a single organisation who can be categorised as second-generation teleworkers as per the definitions in Table 1. This could imply that some organisations either conduct work that is not conducive to effective teleworking or that some management input is required in order to create a healthy, flexible working arrangement. Notably, the experience of second-generation teleworkers differs from that of third- and fourth-generation teleworkers, and it remains to be determined how to apply findings of this type across the telework generations defined in this present study. Furthermore, some employees report an increased sense of role ambiguity when teleworking, which can add to stress and have a negative effect on the employee's well-being, reliant upon increased management input in order to mitigate [16,80]. This supports research by Mann and Holdsworth [63], who found that teleworking can cause a variety of negative emotions in employees, with respondents reporting a lack of role enjoyment and fulfilment and a subsequent increase in worry, resentment, frustration, and loneliness. Whilst not all of these findings are applicable to the modern construction sector, it is important to consider potential risks to the employee when discussing teleworking industry wide. The factors discussed must be mitigated to ensure the long-term success of teleworking in the construction sector.

Research reveals that employers (specifically chief executive officers (CEOs)) are more resistant and look less favourably at teleworking. Peters and Heuskinveld [81] found that CEOs were less receptive than human resources (HR) Managers to teleworking but simultaneously more aware of peer organisations' propensity to offer flexible working. This suggests that HR managers are more cognisant of market forces and pressure from peer organisations impacting employment [77]. Conversely, CEOs are aware of competitors not offering flexible working arrangements to employees and the requirement for their own organisation to do so. Notably, having introduced some level of teleworking many companies (particularly SMEs) are sceptical of the palpable benefits when surveyed, with some suggesting they may not wish to continue it and with others suggesting that any increase in employee performance is irrelevant to their decision [82]. Aguilera et al. (ibid) cited reasons for adoption reluctance that included: (i) a lack of willingness to invest in enablement; (ii) a perceived reduction in employee productivity; and (iii) a requirement to control employees at work. Such reticence was not due to the effectiveness of implementing flexible working intraorganisationally but rather reluctance to continue due to prejudice and expenses. This contradicts other research, which found a lower barrier to investment in technology [25] and the positive perceptions of employees [8,27,77]. These findings highlight that a lack of understanding from companies, and a disparity between perceptions of CEOs, HR Managers and employees, are all factors limiting the adoption of teleworking within the employment market. Resultant of reviewing extant literature, a meta-analysis is required to establish the general consensus amongst literature discourse regarding the adoption of teleworking.

4. Industry 4.0 Construction

Humanity resides at the beginning of a fourth industrial revolution more commonly known as Industry 4.0 [83,84], an inevitable result of several key technological breakthroughs that have changed economic, social, and political development. Schwab [12] proposes that the drivers of these breakthroughs fall into three categories, namely: (i) digital; (ii) physical; and (iii) biological, and that the implications of these technologies will shape industrial workflows moving forward. Proponents of Schwab's theory have since examined the specific impact of applying Industry 4.0 principles to various different work sectors. For example, examining its impact on the role of performance and industrial workflows within the context of the construction industry [15,85,86]. It has also been

examined within the context of product development and manufacturing [87,88] and from a more overarching perspective [13]. These innovations, when examined within the context of construction project workflows, are impactful on the ability of construction professionals to telework effectively and efficiently. The advent of faster and more efficient networking has increased data transfer efficiency, which enables more complex remote working. This technological development has positively impacted manufacturing processes within construction supply chains. For instance, Internet of Things (IoT) technology facilitates almost instantaneous 'industrial communication' between 'everyday internet-enabled devices', to create a manufacturing cloud where data and information are stored and processed to simplify the manufacturing process [87]. In conjunction with manufacturing execution systems (MES), this information can be controlled in real time and used to update long-term production scheduling [85]. This coalescence of technologies could produce an 'integrated production and logistics' model within the wider manufacturing sector [87,89], thus eliminating processes from the supply chain (i.e., transferring goods from manufacturers to third-party logistics organisations). There are also examples of Industry 4.0 technologies that are already implemented. Cryptocurrency markets employ blockchain technology to demonstrate the capability of digital technology in practice, with a single bitcoin reaching a value of USD 19,140.76 on 17 December, 2017, and a typical market value of between USD 5000 and USD 10,000 over the following three years [90]. However, blockchain technology has capabilities that far outstretch mere cryptocurrency exchanges. Blockchain is a public-permissioned and decentralised ledger system allowing for transactions to be processed transparently and without input from third parties [91,92]. Everyone within the blockchain ecosystem has access to the transaction information contained within the ledger, and it can be limited to include only the desired participants [87,91], for example, financial controllers of companies within a construction supply chain, or a main contractor and their subcontractor. There are three levels to blockchain, for which definitions are cumulative. Blockchain 1.0 technology dictates the ability of bitcoin to exist through decentralising the supply of the currency. Blockchain 2.0 facilitates transactions within the currency ecosystem, providing the mechanism (e.g., smart contracts, decentralised organisations and companies) for managing a market within the context of a decentralised economic ecosystem [92,93]. Blockchain 3.0 provides the necessary mechanics for justice services within (and potentially beyond) the scope of a decentralised economy, providing a decentralised repository of information that is universally permanent and publicly auditable [92]. Such a system could help eliminate corruption in the construction industry [94].

Industry 4.0 and Teleworking

There are various applications of Industry 4.0 within the construction industry. Oesterreich and Teuteberg [15] reviewed Industry 4.0 applications within construction supply chains and developed a theoretical model for delivering value to the construction process. It is theorised that various stakeholders within the construction supply chain and stages within the construction project process are involved in engineering value using Industry 4.0 specific technologies through workflows and processes. They conclude (ibid) that adoption of these innovative technologies and processes in construction firms was, at the time, lagging behind technological development due to: (i) hesitation within firms to adopt new technologies with unclear benefits; (ii) reluctance to make the necessary organisational and process changes; (iii) lack of accepted standards to reference; and (iv) concerns about data security. These reasonable concerns within organisations are similar in nature to concerns regarding teleworking adoption within organisations, which are discussed later in this present study. To visualise the adoption process, it is helpful to consider the accepted project process delineated within the Royal Institute of British Architects (RIBA) plan of works [89] and apply specific processes to establish the key areas where Industry 4.0 enabling technology can be applied to improve workflows. This formed part of the research of Oesterreich and Teuteberg [15]; however, their proposed model has been expanded upon given rapid technological developments made. Thus, Figure 2 demonstrates the

cumulative effect of integrating Industry 4.0 technology into each stage within the RIBA Plan of Work [95], where enabling teleworking is a primary goal.

The framework presented in Figure 2 demonstrates that minor workflow changes can have a cumulative effect on the ability of a construction professional to telework. The relative complexity of these changes varies depending on the profession or RIBA stage focused upon. For instance, at the pre-tender stage, various stakeholders (e.g., architects, cost-consultants and the client) utilise a mixture of: (i) virtual meetings [96]; (ii) cloud storage to exchange information digitally [66,67]; and (iii) Building Information Modelling (BIM), in order conduct their business without the necessity of meeting face-to-face.
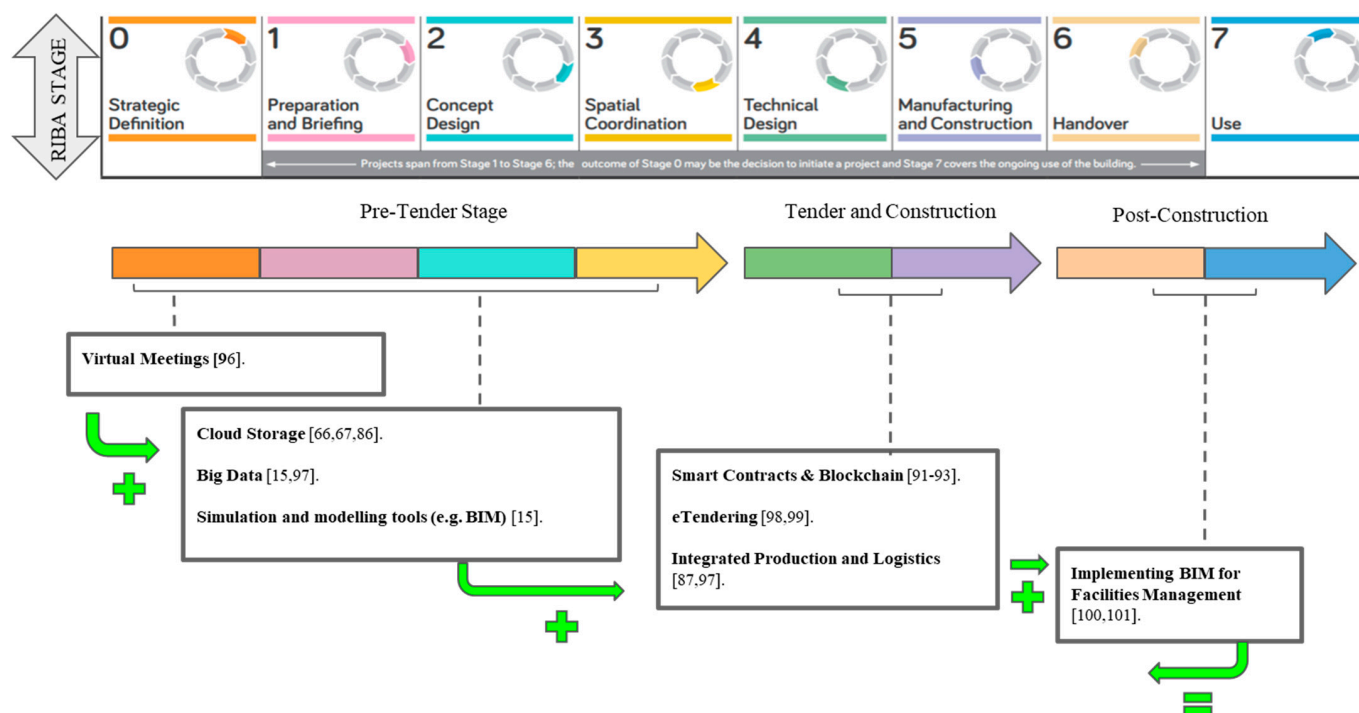

Figure 2. Cumulative effect of applying Industry 4.0 principles to achieve a teleworking environment within a construction project (traditional procurement) [15,66,67,86,87,91–93,96–101].

This modus operandi may impact the quality of project interaction (i.e., focusing on quality of information exchange) [8]—understanding this questions the necessity of employer provided work space. These employees are: (i) not guaranteed to work within the same organisation; and (ii) may feel that a flexible working arrangement may increase their autonomy, positively impacting their role performance [8,26,77]. In later RIBA stages (such as tendering and construction), processes are cumulatively applied. Smart contracts and blockchain technology [91–93] could eliminate processes from the main contractor and subcontractor workflows allowing for more efficient contract administration. Furthermore, the use of eTendering [98,99], along with virtual meetings and cloud information exchange, removes the need for face-to-face interaction when tendering. As discussed, some studies have shown that face-to-face interaction fosters better quality relationships [102,103]. However, in the context of teleworking in a modern and agile industry, the employer's requirement to provide space to carry out duties related to tendering is questioned by technology, especially when considering the aforementioned benefits namely: (i) reduction in commuting [64]; (ii) increased job satisfaction [8,26]; (iii) more efficient intraorganisational communication [8]; and (iv) the ability of companies to offer more competitive roles to the job market [7]. As the technologies discussed in this model become more prevalent, it will become increasingly difficult to justify inflexible working arrangements within many organisations, particularly in the context of a post-COVID employment market [29–32].

5. Scopus Sampling and Scientometric Analysis

The initial dataset of articles was extracted from Scopus (12 March 2021) using the pertinent keywords telework 'OR' teleworking 'OR' telecommute 'OR' telecommuting. Scopus was used because it is widely regarded as one of the most comprehensive and complete journal databases available [104,105] and provides user-friendly analytical tools that are helpful to visualise voluminous extant literature [106]. As the manual literature review alluded to a generational trend for the progression of teleworking, manipulation of the sample was avoided, instead allowing VOSviewer to examine all publications for prevalence within the prevailing body of knowledge. VOS viewer is capable of extracting only publications linked by the specified fields selected when conducting analysis [48], and therefore, overspecifying the dataset would be unproductive in this instance.

5.1. Co-Citation Networks

The first stage of co-citation analysis ascertained the most frequently cited and published authors within the dataset to pinpoint the foundational research for the topic. These findings are summarised in Figure 3. Figure 3A visualises the largest co-citation network of authors in the dataset can be observed, with larger nodes denoting higher citation counts. This network of authors has cooperated to produce over 350 linked publications since 1975, and this forms the backbone of English-language teleworking research. The findings are quantified in Figure 3B. The largest node in the network belongs to Dr Patricia Lyon Mokhtarian of the Georgia Institute of Technology who has 43 publications, 40 within the cluster (quantified in Figure 3C), making her the most prominent scholar within the network. Dr Mokhtarian's research largely focuses on transportation (specifically commuting habits), and her publications do not always relate to teleworking per se, with many focusing on infrastructure and transport. Dr Viswanath Venkatesh is another prominent scholar whose research regarding consumer acceptance of information technology has over 1000 citations from just three items within the dataset, underscoring the influence of this research. The most cited of these, "Creation of Favorable User Perceptions: Exploring the Role of Intrinsic Motivation" [107], details the future of the digital workplace (as perceived in the late 1990s) and presents an early concept of what we know today as third and fourth generational teleworking (Figure 2). This article has 839 citations within the network. Notably, of the top three most cited authors in the network, two are not specialised in teleworking research and demonstrates the cross-disciplinary relevance of teleworking research. In contrast, Professor Timothy Golden of the Lally School of Management has spent over 20 years specifically researching teleworking and has published 16 articles in the cluster with over 1000 citations in the network.

As aforementioned, Dr Golden and Dr Mokhtarian are key scholars within the research domain. The distance between their respective nodes (on either side of the cluster) shows a lack of interaction between them. However, there is significant density in publications centrally, with a multitude of authors being shown to have cited both in their publications. This in addition to the density of the cluster, shows a strong foundational research domain, with authors citing from a multitude of perspectives. This is further shown in the density of the source co-citation cluster, which demonstrates a strong use of multidisciplinary source material in the extant literature. Cumulatively these data demonstrate an inter-industrial relevance, and in light of recent developments and the COVID-19 pandemic, it is likely that this will become more prevalent. The most cited sources within the dataset can be analysed as before, the purpose being to identify a variety of perspectives from which the subject of teleworking has been (or can be) considered.
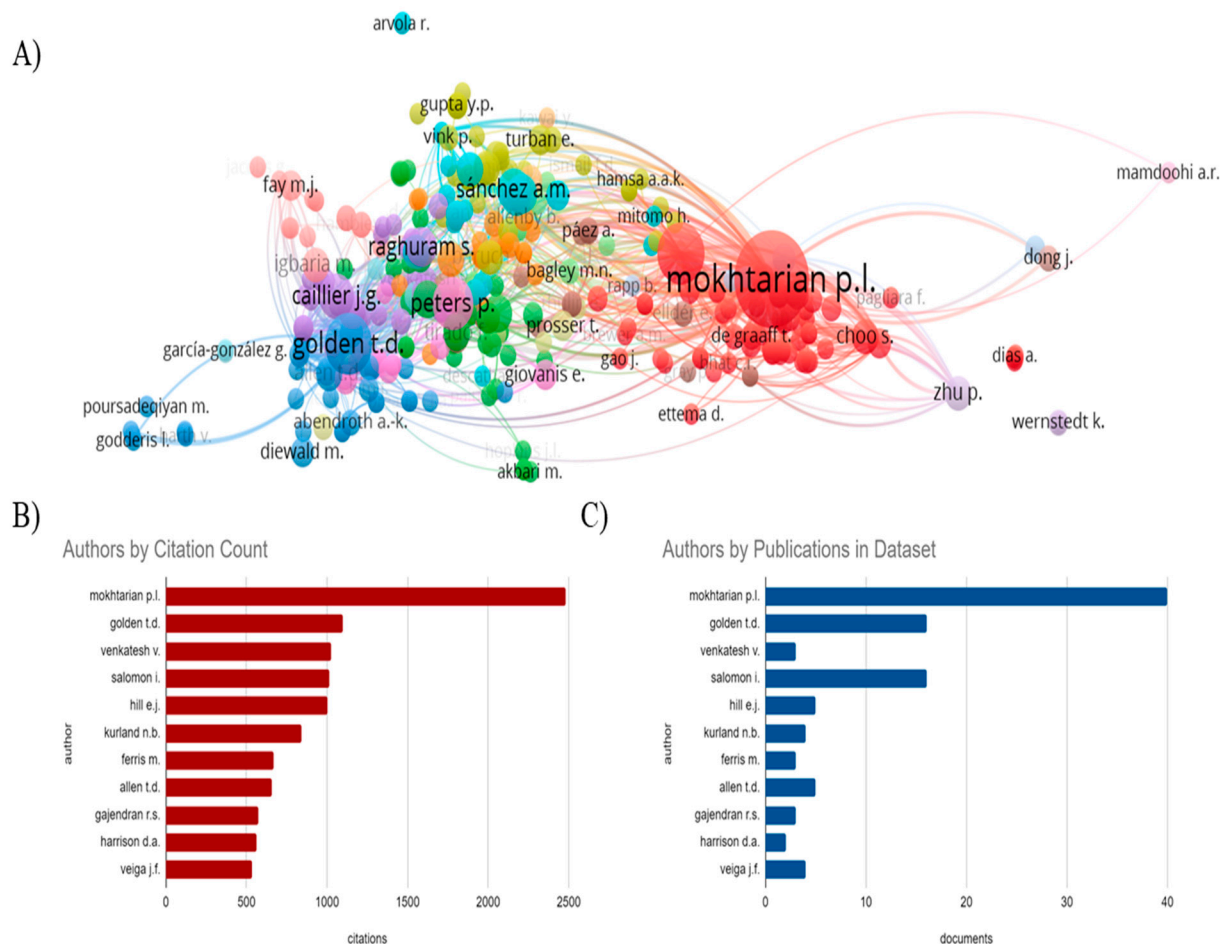
Figure 3. Teleworking authors and articles by citation count. (**A**) shows the largest network cluster for sources within the dataset, (**B**) shows author citation count and (**C**) shows authors by publications in the dataset.

Cumulatively, these data demonstrate an inter-industrial relevance, and in light of recent developments and the COVID-19 pandemic, it is likely that this will become more prevalent. The most cited sources within the dataset can be analysed as before, the purpose being to identify a variety of perspectives from which the subject of teleworking has been (or can be) considered. Figure 4A shows the largest network cluster for sources within the dataset, Figure 4B shows author citation count and Figure 4C shows authors by publications in the dataset. Notably, in Figure 4A the colour denotes different publication topics, for instance the green nodes reflect publications specialising in transportation research, while the blue nodes denote employment and industrial research. The plethora of colours shown in the figure demonstrates the cross-disciplinary relevance of teleworking research. The relative density of the cluster denotes a high cross-citation interaction between publications, which indicates that the research domain is utilising the benefit of varied source material to form a cross-disciplinary consensus among researchers.

The largest node in the cluster denotes New Technology, Work and Employment. This is reflected in the graphs in Figure 4, which show approximately 2000 citations and 43 publications for this source, respectively. Whilst conceivable that an employment journal has the most citations and publications in the network, other prominent sources include: (i) Journal of Vocational Behavior; (ii) Journal of Applied Psychology, Transportation; and (iii) Management Information Systems.
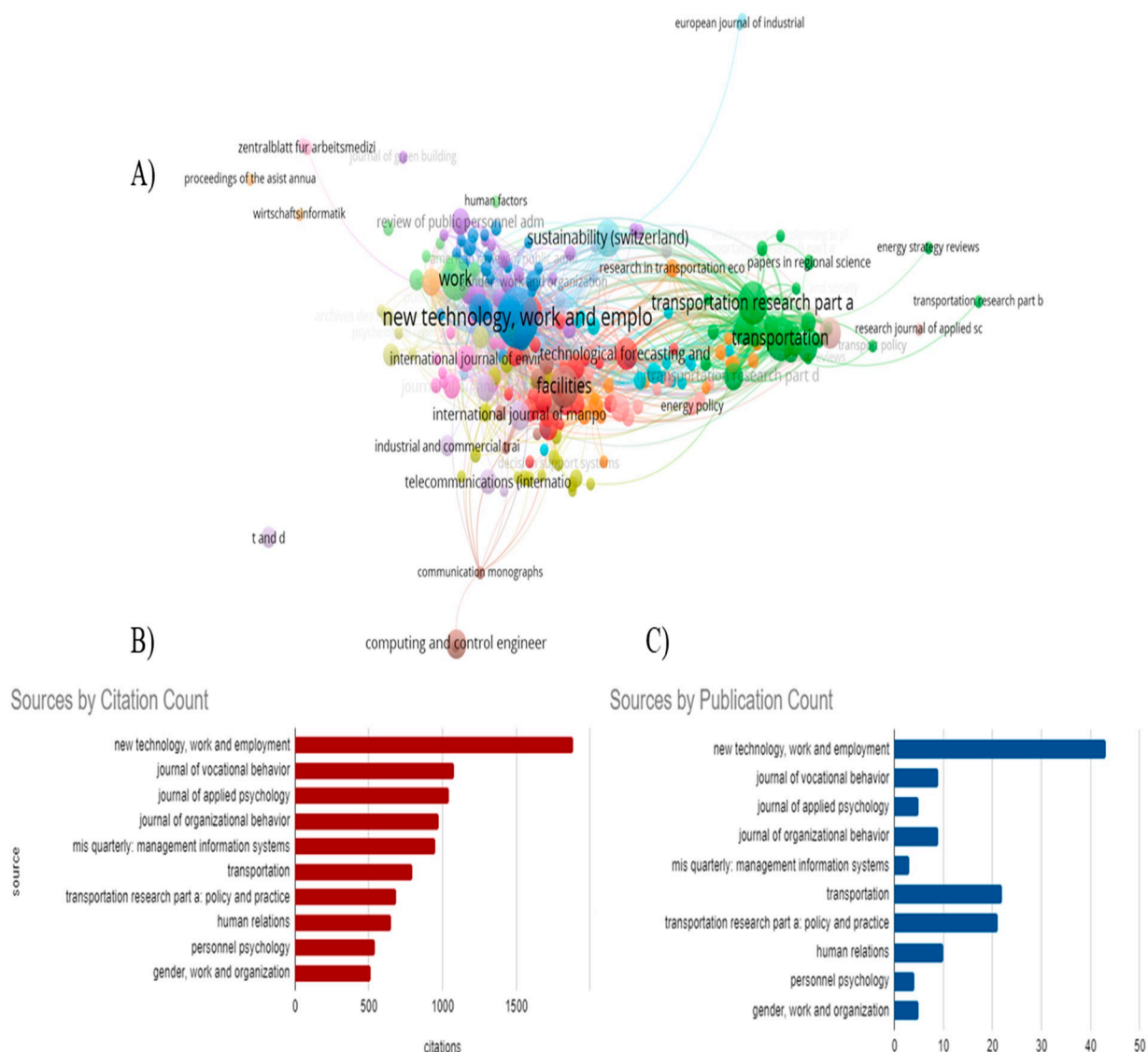
Figure 4. Teleworking sources by citation count. (**A**) shows the largest network cluster for sources within the dataset, (**B**) shows author citation count and (**C**) shows authors by publications in the dataset.

These journals cover topics from psychology to human resources and information technology, contributing diverse perspectives to the research domain. Future research discussing the viability of teleworking research within a specific industry would require further consideration than simply economic or productivity factors. Therefore, it is important to understand that foundational research appears to exist in a variety of different disciplines.

5.2. Analysis of Keywords

A two-stage process was used to analyse keywords. First, comparing the keywords as selected by each author, demonstrating the intentions of contributors (Figure 5). Second, an examination of keywords within the abstracts and the full text of a smaller sample was undertaken to uncover emergent themes for future investigation. This process required the use of Voyant Tools to analyse large quantities of text. To adequately visualise keywords in the sample, both link strength (VOSviewer) and prominence (Voyant Tools) were essential metrics to discuss to fully capture the information.
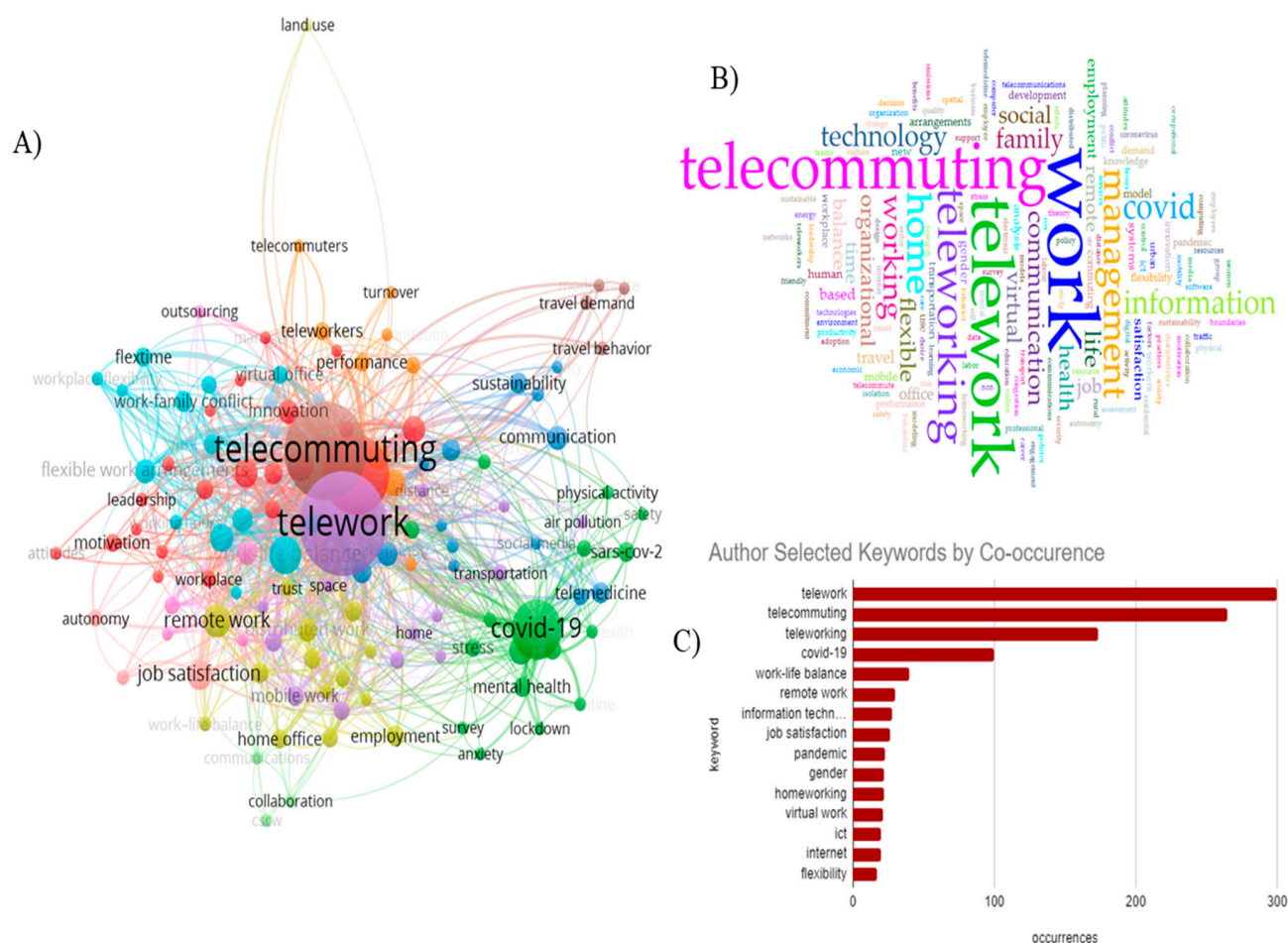
Figure 5. Author keywords. (**A**) shows the largest network cluster for sources within the dataset, (**B**) shows author citation count and (**C**) shows authors by publications in the dataset.

Keywords within the dataset follow clearly defined groups (Figures 6 and 7). For instance, words denoting the study of role performance capability (e.g., work/life balance, job satisfaction, workplace flexibility, etc.) show equivalent prevalence to those related to transport (e.g., travel behaviour, commute, emission, and trip) and those related to technology (ICT, internet, and virtual work), further demonstrating the scope of relevance when discussing teleworking. Notably, the keyword group related to legislation (e.g., policy and change) may indicate that some academics are looking to influence legislation through published research denoting a future research topic that defines what changes are required in employment law to facilitate more teleworking and a reduction in commuting. Finally, and counterintuitively, one of the most prevalent keywords in the sample is COVID-19, with this being the fourth most popular author keyword (Figure 5C) and the second most frequent keyword in abstracts (Figure 6C).
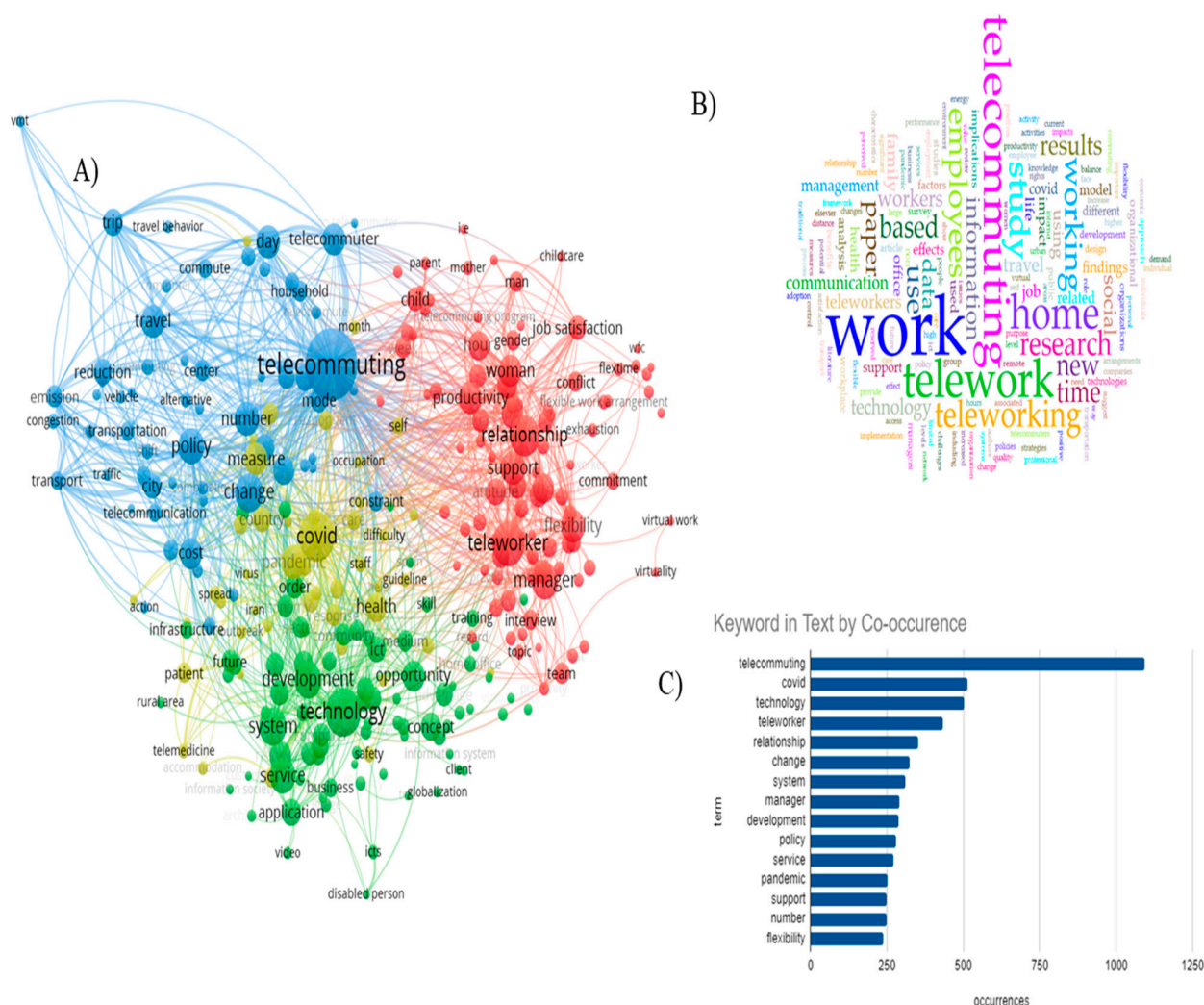
Figure 6. Article abstract keywords. (**A**) shows the largest network cluster for sources within the dataset, (**B**) shows author citation count and (**C**) shows authors by publications in the dataset.

The observation of a contemporary theme such as teleworking having such prominence within a longitudinal sample (1975–present) is a curious finding. This may indicate an increase in teleworking research because of the shifting work environments due to COVID-19. This was the prompt for further analysis (Figure 7) to look at publications over time. Figure 7 details the sample by publication date. With over 20% of the sample being published since January 2020 (Figure 7A), almost 300 publications (Figure 7B), confirms that the COVID crisis has led to a surge in publications regarding teleworking, possibly indicating a change in working practices that are already firmly established.

Having conducted extensive scientometric analysis, the research domain has a strong foundation and is commencing a critical period. With the wealth of new data on the practicality, impact, and reality of teleworking on a substantive scale, it is understandable that researchers are taking the opportunity to explore the domain and contribute. Continuing progress on teleworking research, further understanding how or whether to adopt more regular teleworking in many industries, including construction, will engender greater academic discourse and subsequent societal benefit.
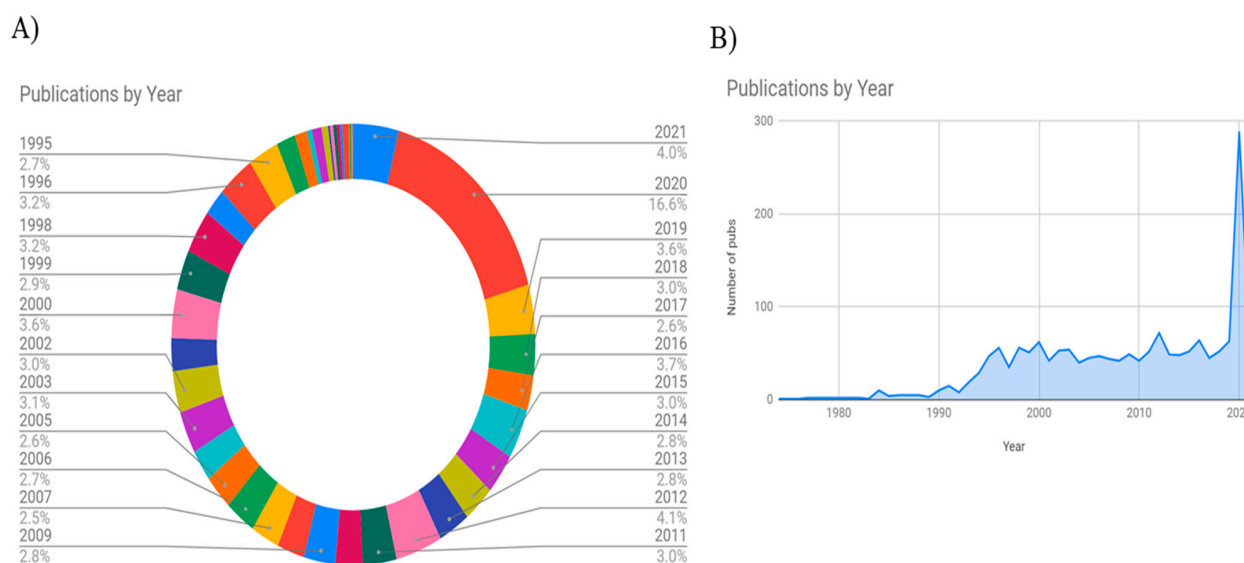
A)

Publications by Year

B)

Publications by Year

Figure 7. Sample publications by year.

The question is, will industry and commerce revert back to the traditional approach to working or is technology augmented teleworking here to stay? Future research is required to answer this research question definitely.

6. Discussion

Conducting research with a focus on the construction industry allows for the implications of the findings to be contextualised and applied specifically, rather than generalising all workplaces. It has been demonstrated that cloud technology and software solutions [66,67,86] and advances in computing power [70,71] provide a platform for adoption within the construction industry. Furthermore, by applying the industry-accepted model depicted in the RIBA plan of works [95], in conjunction with the technological advancements uncovered through literature review, a distinct model for limiting physical commuting on a construction project has been theorised, adoption of which could be the subject of future research to ascertain viability. Moreover, the ongoing COVID-19 pandemic has questioned the necessity of physical commuting [29–32] and could potentially cause a shift in peoples' perceptions of teleworking as a long-term solution. Many commuters may struggle to apprehend why, after over a year of seemingly adequate role performance whilst teleworking, they are required to return to the physical office. The end of the COVID era may provide a watershed moment for commuting in the UK and perhaps lead to fundamental changes in the way roles are performed. The model proposed in this research may assist in overcoming the challenges this poses.

6.1. Theoretical Implications

Having expanded upon the generational model proposed by Messenger and Gschwind [25], this research has provided a model for assessing the chronology of the evolving teleworking environment. This combines technological advancements with anecdotal evidence gathered during each of the proposed generations of research to create a comprehensive assessment of the evolution of the home office. Applying this knowledge to past research will facilitate future researchers to contextualise extant literature when considering the future of teleworking. Many studies, particularly those relying on respondents and surveys, are still valuable and when considered alongside the generational model (Figure 1) can be fully assessed. For instance, teleworkers from the early 2000s may respond differently when considering their role performance capability to their counterparts in 2021. However, lessons from their family or social interaction are applicable across generations.

When discussing a topic as complex and technologically reliant as telecommuting, this context is invaluable.

Additionally, the observation of the wealth of new literature regarding teleworking that has emerged (resultant of the COVID-19 pandemic) may facilitate an unprecedented acceleration of the research domain moving forward. Crucially, conclusively demonstrating this phenomenon denotes the commencement of a new era in teleworking for research (Figure 1). The fifth generation of teleworking may be more about perception than technology, and in order to reach the potential that has been demonstrated during the past year, gaining a clear picture of the findings from this large subset of articles published since 2020 is critical to progressing the research domain forward into 'the new normal'.

6.2. Limitations

Limitations were uncovered within the extant data utilised in the study. The technological capability of the average home office, satellite, or mobile teleworker has been constantly evolving since the phrase was first coined in 1975. This presents a problem because research has often had to re-examine fundamental concepts and definitions, updating them to allow for this continuous technological improvement. Equally, role performance and job satisfaction are subjective, and thus, providing definitive conclusions are problematic as every worker has a different experience. This is compounded by the fact that findings on individual role performance from any study that relates to first- or second-generation teleworkers, whilst relevant for providing foundational information, are likely no longer applicable at face value because the experiences of fourth-generation teleworkers are vastly different. Importantly, ascertaining what the subjective experience is for large cross-sectional samples to capture the viability of fourth generational teleworking as an alternative for the traditional 'office-based' model of employment. It appears that these data may be on the horizon with the influx of new research since 2020 and that it will become available post-pandemic. It is likely that a consensus will be reached on whether teleworking is viable in a multitude of working scenarios and for employees based on their home office conditions (including those employed in the construction sector).

7. Suggestions for Future Research

Future research should focus on case studies for adoption of teleworking practices at the organisational level and demonstrate the impact on individuals, companies, and projects when the majority of those involved are telecommuting. This should take into account individual circumstances and look at multiple cases of various roles or industries. This proposed case study would require deductive reasoning and empirical analysis to develop an overarching model that could compare and contrast between individuals and companies to determine the optimum usage of teleworking practices. Such work could then support the development of prescriptive guidance for both employers and employees on how to maximise teleworking for the benefit of the individual and organisation. Furthermore, a manual review of literature pertaining to Industry 4.0 in the construction industry has established that extensive technology already exists to enable teleworking in a dynamic and project led industry, and research into the application of a model (perhaps similar to that proposed in Figure 2) in the future by an industry body such as Royal Institution of Chartered Surveyors (RICS) or Chartered Institute of Building (CIOB) could lead to a culture of acceptance helping further modernise the industry.

Further research is required to compare costs associated with the provision of office space to the cost of providing suitable office equipment for use at home and the challenge of supporting staff that do not have access to significant space to permit home working. It is likely that this situation has arisen during the COVID-19 pandemic. Therefore, a sample of employees who telecommuted during the pandemic, but who had spatial constraints and their employers, could be interviewed in order to develop a solution for this problem. Furthermore, many employers will now have an understanding of the impact on their productivity as a result of having large numbers of employees teleworking. Future research

should compare the cost of providing a space in which to work against any actual or perceived cost associated with diminished or increased role performance.

Whilst there are demonstrable benefits of teleworking—including increased role performance and job satisfaction [8,26,77], a reduction in commute time [64], and the retention of high-quality staff [7,77]—many studies, particularly those carried out during the second generation of teleworking and before, rely on limited samples of employees using technology that has since been superseded. Future research should examine the relationship between role performance and the availability of systems and technologies that enable remote work and how employees were able to utilise them during the pandemic.

8. Conclusions

This research sought to conduct extensive manual and scientometric literature analysis to establish the extant understanding of teleworking in English-language publications. Manual analysis showed that although progression of enabling technology over time has been extensive, this has been somewhat hindered by the perception of teleworking from employers who are often reluctant to allow their staff flexible work arrangements. This was discussed in more detail, highlighting specific advancements in technology applicable to role performance in construction professions. It is also notable that a lack of financial and environmental information from within specific organisations makes it difficult to quantify the economic benefit and deleterious environmental considerations of adopting flexible work policy within specific companies. By forming both the definitions for the generational progression of enabling technology for teleworking (Figure 1) and the cumulative effect of applying Industry 4.0 principles to achieve a teleworking environment within a construction project (traditional procurement) (Figure 2) theoretical models, this research has been contextualised and can be taken forward in conjunction with COVID and post-COVID studies [108].

Further scientometric analysis uncovered that the recent global pandemic has resulted in an influx of new information, new teleworkers, and subsequently has pushed the research domain forward at an unprecedented rate. With over 20% of the data sample being published since January 2020, and as further research emerges, it will become possible to develop a consensus regarding the practicality of teleworking on a large scale. This will help to bring the research domain forward from anecdotal samples to creating models from which employers can utilise to implement teleworking in their organisation.

Scientometric analysis shows that the teleworking research domain is at the beginning of what could become a formative time period, and once the current COVID-19 crisis concludes, it will be interesting to see what insights have been gained.

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