

Review Paper

The Impacts of ICT on Urban Travels: A Significant Shift during the Covid-19 Pandemic

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Abstract

Transportation is one of the most important issues in today's cities. Urban trips and their spatial and temporal patterns influence and are influenced by other components and functions of the city. Information and communication technology have evolved rapidly over the last few decades and have influenced urban travel patterns in many ways. Numerous studies have attempted to study the effects of these technologies on transportation and urban travel and to explain the relationship between them. However, due to the lack of sufficient information and the complicated nature of the connection between ICT and travel, there is still speculation about how it will affect the urban travel patterns, and many researchers believe that we can not simply comment on these effects conclusively. Hence, understanding the interaction of ICT and urban transportation is necessary for the planning and management of urban transportation. This study tries to answer the question of what is the relationship between IC and urban travel through a systematic literature review of empirical studies? For this review, 77 empirical published articles were selected and after describing their important features, the main findings of the articles were extracted and categorized into 6 topics based on the effects that ICT can have on urban travels and the relationship between them. The findings showed that the relationship between ICT and urban travel can be in four different modes: a) substitution-reduction, b) synergy-complementary, c) modification, and d) neutrality. ICT can also influence the urban travel pattern and its quantity and quality by providing fragmentation of activities and optimizing the use of the existing transportation systems. The type and severity of effects can vary at different times and places and under the influence of socio-economic factors. The results also indicate that due to the significant increase in ICT use after the Covid-19 pandemic, the severity of its effects on the urban travel pattern has also increased and it is expected that even after returning to normal and in the post-Covid-19 period, the relationship between ICT and the travel patterns will become even more pronounced.

Keywords: *Information and communication Technology (ICT), Urban travel, Covid-19, Literature review.*

1. INTRODUCTION

Increasing the development of ICT and information evolution is perhaps the most recent major development that cities are witnessing. Digital technologies have revolutionized lifestyle (Aguilera et al., 2012; Lyons et al., 2018) and the majority of activities. ICT has challenged our understanding of traditional roles (such as the home) (Wang et al., 2015) and disrupted the traditional divisions of activities (Hubers et al., 2006; Mokhtarian et al., 2006) by

increasing the flexibility of activities (Andreev et al., 2007; Lee-Gosselin & Miranda-Moreno, 2009), introducing a new type of actives (Kakihara, 2003; Mokhtarian & Salomon, 2002; Näsi et al., 2012), multitasking (Schwanen et al., 2008), fragmentation of activities (Hubers et al., 2006; Xi et al., 2017), and spatial/temporal reorganization of activities (Lenz & Nobis, 2007).

ICT has increased the flexibility of activity, time, and space (Dijst, 2009; Kwan, 2006; Talvitie, 2004) and undermined the traditional links between them

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(Bibri & Krogstie, 2017). In this context, space dominates over time, and consequently, the spatial patterns of activities dominate over the physical limitations of proximity (Gepts, 2002), and more flexibility and fewer geographical constraints alter the traditional rules in choosing the location of firms (Moriset, 2003; Song & Liu, 2013) and even the residential location of individuals (Sohn et al., 2002; Talvitie, 2002). In this regard, some scholars believe that ICT development and expansion of its use will eventually eliminate the separation of work and residence (Meshur, 2013; Mitchell, 1999; Moss & Townsend, 2000). All these can fundamentally influence travel behavior and urban travel patterns. Today, physical urban space has merged with virtual space and created a new concept known as “hybrid space” (Audirac, 2002). In the ICT era, accessibility can no longer be assessed through the calculation of time, distance, and travel costs (Golob, 2002). The possibility of carrying out activities from a distant location with no necessity for physical travel (Lila & Anjaneyulu, 2013) has transformed the concept of accessibility (Lu et al., 2014; Scott, 2000; van Wee & Chorus, 2009), and, the change in the concept of access transforms the travel patterns (Lu, 2015). In general, ICT provides choices for households and businesses and opens up the operating environment, unlike the old communication infrastructures. In this context, access to jobs and facilities is easy for users.

The shift from traveling by car to electronic communications is a change to a higher speed, which in turn leads to increased accessibility (Drewe, 2001). On the one hand, ICT can affect driving factors and motivations for traveling. On the other hand, it leads to more efficient use of the existing urban transportation infrastructures. In recent years, a significant amount of theoretical literature has been formed on the influence of ICT on individuals’ travel patterns (Bhat et al., 2003; De Graaff & Rietveld, 2007; Kenyon & Lyons, 2007; Kim & Goulias, 2004; Kwan, 2007; Lenz & Nobis, 2007; Nobis & Lenz, 2009; Srinivasan & Raghavender, 2006; Thulin & Vilhelmsen, 2007). However, due to the lack of sufficient information and the complicated nature of the connection between ICT and travel, there is still speculation about how it will affect the travel patterns, and many researchers believe that we cannot easily conclude these influences (Kwan et al., 2007).

In fact, although significant studies have attempted to study the impacts of ICT on urban travel, the difference in the findings of the empirical studies has left no accurate answer to the questions of what ICT has to do with urban travel patterns and what changes will occur in urban travel patterns as the use of these technologies increases dramatically. The Covid-19

pandemic has greatly increased the quantity and quality of ICT use over the past two years, and the capabilities of these technologies are being used around the world to overcome the constraints caused by this pandemic. During this period, telecommuting and teleworking, e-learning, online shopping, online entertainment, tele-activities, etc. have seen such an increase that it can be said that dramatic changes have taken place in human lifestyle, especially in cities. Since these changes have impacted the way of doing things and the traditional patterns of work and activities, they will have consequences on the urban travel and transportation patterns. Hence, understanding the interaction between ICT and urban travel is necessary for the planning and management of urban transportation. Considerable differences in the results of empirical studies and their thematic and methodological diversity hinder the urban planners and managers to generalize and leverage their findings. This study tries to review the findings of empirical research that have studied the relationship between ICT and urban travel and provide a relatively complete summary of them through a systematic literature review. Also, attempts have been made to study the consequences of the Covid-19 pandemic as an aggravating factor in this regard. In order to provide a better understanding of these studies, some of their important features such as the geographical dispersion of case studies, the central theme of the articles and the analytical models used by them have been reported.

2. THE RELATIONSHIP BETWEEN ICT AND URBAN TRAVEL

With the creation of cyberspace and the expansion of ICT, we have formed a non-geographical domain in the information and electronic networks, in which there are no space and distance constraints, and time plays a central role instead of distance (Al Ani, 2012). ICT influences accessibility by reducing the necessity and importance of physical proximity. It has made it possible for individuals to travel simultaneously in the real and virtual worlds (Ghorbani et al., 2013). This technology has provided more flexibility for the users in the selection of time and manner of travel (Yuan et al., 2012). Thus, it can, directly and indirectly, influence the patterns of urban travel and affect the overall travel demand (Falch, 2012) and the how of the travel.

The indirect influence of ICT on transportation appears in changes in the land use pattern and the activities organization. Tele-working, electronic commerce, internet-based services, email, lifestyle change, etc. all have an impact on transportation

(Höjer, 2000). These influences may be seen in different forms of substitution (Douma, 2003; Kwan, 2006; Nobis & Lenz, 2009; Pendyala et al., 1991), and complementarity and synergy (Hjorthol, 2005; Lyons, 2002; Mokhtarian & Salomon, 2002; Wang & Fion Yuk Ting, 2007; Zhang et al., 2007). However, given the complicated nature of the interaction between the use of ICT and travel behavior, simply concluding on the way ICT influences daily activities remains doubtful (Aguilera et al., 2012; Dadashpoor & Yousefi, 2018; Hjorthol & Gripsrud, 2009; Kwan et al., 2007; van Wee et al., 2012; Yousefi & Dadashpoor, 2020; Yuan et al., 2012).

ICT can increase the efficiency of transportation network (Annino & Cromley, 2005; Chorus et al., 2007; White Iii, 1995) and help the optimal use of transportation infrastructures through the distribution of travels across different transportation systems and management of time and travel path (Lu, 2015; Zhu, 2011). Besides, ICT applications may reduce the general costs of transportation by choosing shorter paths or increasing the ease of travel (Lila & Anjaneyulu, 2013; Van Wee et al., 2013). ICT has also caused the temporal flexibility of travel; thus, it can minimize peak hours' traffic by distributing the travel throughout the day (Hjorthol, 2002; Hong, 2002; Pendyala et al., 1991; Zhu, 2011). On the other hand, due to the availability of ICT while traveling, carrying out certain activities during that time (multitasking) becomes possible, which leads to saving time and increasing efficiency (Ettema & Verschuren, 2007; Golob, 2002; Kenyon & Lyons, 2007; Mason & Deakin, 2001). Here, the most influential factors on the relationship between ICT and urban travels are classified into seven categories:

2.1. The Shift in the Concept of Accessibility

Before the digital age, accessibility was determined by physical distance, quality of movement, and how that distance was traveled. But, in the digital age, access in urban space is integrated with virtual access, and with this new form of communication, the cornerstone of the traditional economic-social geography can no longer be responsive to the information age (Audirac, 2002). ICT potentially influences all aspects of the concept of access (Van Wee et al., 2013). Today, access cannot be assessed solely based on time, distance, and travel costs (Graham & Marvin, 2002). Technologies such as mobile phones, private computers, and the internet have facilitated the activities, and many activities can be performed with no necessity for physical access (Lila & Anjaneyulu, 2013). By the way, the positive influences of ICT on access defers depending on the

limitations and the selections of the travelers (Lu et al., 2014).

2.2. Activity and Teleworking

Teleworking (telecommuting) is one of the new applications of ICT that has influenced traditional work methods. Although teleworking existed before technology advancements and its remarkable expansion in the 1980s and 1990s, ICT has been the main cause of the progressive growth of teleworking and its increase in total employment (Mello, 2007; Minsky, 1980; Tung & Turban, 1996). By providing more flexibility for enterprises and their staff, which can lead to better work conditions (including work hours, work experience, etc.), ICT has improved work conditions and reduced traffic and air pollution (Manuela Perez et al., 2004; Yen & Mahmassani, 1997). Teleworking can also lead to the reduction of travels, traffic (Falch, 2012; Hubers et al., 2006), average traveled distance (Ferrell, 2005; Helminen & Ristimäki, 2007), and also to the reduction of fuel and time consumption (Lila & Anjaneyulu, 2013). Since the 1980s, teleworking has emerged as an international phenomenon, and governments supported it in favor of a wide range of social and organizational objectives, as well as to reduce traffic-driven problems (Mello, 2007). Teleworking as a choice (Asgari et al., 2014) enables people to reside in more appropriate but distant places with less undesirable environmental effects (Mokhtarian et al., 2004). This phenomenon can, therefore, accelerate the trend of urban development towards decentralization (Muhammad et al., 2008; Muhammad et al., 2007).

2.3. Shopping

There are argumentations that online shopping has reduced shopping trips (Cao, 2009; Ferrell, 2005; Weltevreden & Rietbergen, 2007) and influenced the traditional way of shopping (Ding & Lu, 2017), or at least it makes more flexible the shopping time (Cao, 2009) and reduces the traveled distance (Ferrell, 2005). Others believe that online shopping complements traditional shopping (Cao et al., 2012; Rotem-mindali & Weltevreden, 2013) and we cannot expect it to considerably reduce the number of travels or to be considered a solution to traffic problems (Cao et al., 2010). Although a great share of the travels relates to shopping, the savings from online shopping instead of ordinary purchases, even if they are 100% substituted, would not be significant given the fact that shopping is always accompanied by other activities (Falch, 2012). There is still another idea that online

shopping does not affect the number of travels (Bhat et al., 2003), or it may even increase the number of trips (Zhou & Wang, 2014).

2.4. Leisure Time

Despite the quantitative studies on the influence of ICT on amusement and leisure time (Smith & Mountain, 2012), the results showed that ICT highly influences different aspects of these activities (Mokhtarian et al., 2006; NECEA, 2013). New types of recreation (Näsi et al., 2012) such as computer games, new entertainment in smartphones and internet-based amusements (Zhou et al., 2014), virtual tourism, etc. have led to changes in the pattern of the entertainment activities (Andreev et al., 2007) and reduction of activities in other entertainments. Thus, ICT can change the pattern of entertainment trips.

2.5. Communications

Some researchers argue that ICT has no considerable influence on face-to-face communications and personal visits (Gaspar & Glaeser, 1998) and the importance of this type of communication will remain intact (Boiteux-Orain & Guillaud, 2004; Hall, 1999; Lusht & Farber, 1996; Sridhar & Sridhar, 2003). Even the importance of the physical distance can be so great that not only it is not reduced with the expansion of virtual communications, but even these communications are influenced by physical distance and fade away with the increase of distance (Lengyel et al., 2013). Some researchers argue that ICT leads to more interactions and the development of social relations (Zhen & Wei, 2008). By eliminating geographic constraints, virtual interactions provide a way to expand communication (Lu, 2014) and, hence, can complement face-to-face communications (Sridhar & Sridhar, 2003). The results of some studies show that ICT can substitute face-to-face communications (Golden et al., 2008). However, the intensity of these effects depends on the extent to which ICT tools are used (Yin et al., 2011). By facilitating telecommunication, ICT can eliminate the need for certain travels for communication.

2.6. More Efficient Use of Transportation Infrastructures

ICT tools and applications can be used to provide on-site services, inform travelers, and streamline traffic flow. For instance, the position and the number of empty parking rooms, metro/bus timetables, and information on various vehicles are demonstrated on

digital screens or provided for the users through wireless networks (Stadler, 2013). ICT can to a large extent help efficient use of transportation infrastructures, by distributing the travels in various transportation systems, paths, and exit times (Chorus et al., 2007). Besides, ICT applications can shorten the traveling time, facilitate search, and even eliminate the fear of getting lost. Also, it is possible to select the best path both for different travel means (private car, public transportation, air travel, etc.) and combined travels (Van Wee et al., 2013). ICT can respond to some urban transport needs through innovative applications that reduce travel and increase travel efficiency. Through ICT, some benefits of using a private car are achievable in integrated and shared transportation systems (Ericsson, 2014). Today, intelligent transport systems are on the agenda of many cities and play a major role in improving urban transport systems. These systems include a range of wireless and wired ICTs that can integrate with transportation infrastructures and vehicles (Rassia & Pardalos, 2014).

2.7. Multitasking Function and Fragmentation of Activities

Parallel activities while traveling can add to the travel efficiency and, hence, increase marginal trips (Lyons et al., 2007). Multitasking while trips can explain part of the increase in travel time per capita (Metz, 2008; van Wee et al., 2006). Also, the fact that ICT would make possible the multitasking functions while traveling affects the calculations of traveling time costs. In particular, it seems that ICT reduces the value of time-saving traveling by enabling multitasking functions during a trip. Empirical studies show that saving traveling time is more important for people who are not interested in multitasking functions (Ettema & Verschuren, 2007). On the other hand, "fragmentation of activities" and the reorganization of the activities in time and space have become possible through ICT (Couclelis, 2000). Such reorganization affects travel behavior (Lenz & Nobis, 2007).

3. METHODS

This study is a systematic literature review that studied the effects of ICT on urban travels. To this end, the related scientific literature was analyzed and evaluated in a systematic process. The literature review provides a well understanding of the extension and depth of the existing research in a scientific field and illustrates the existing gaps (Xiao & Watson, 2017). A systematic review is a useful tool for improving research knowledge and its application

(Jesson et al., 2011). This type of literature review, by identifying, evaluating, and integrating a set of scientific studies, seeks to provide a scientific and observation-based answer for certain issues (Boland et al., 2017; Fink, 2013). According to the research goal and approach, there are four types of review studies: descriptive, testing, extensive, and critical. The present study is a descriptive review study. According to the process proposed by Xiao and Watson (2017), despite the differences between the various types of literature review, they can all be done in eight general steps: 1) formulating the research problem, 2) developing and approving the review protocol, 3) searching for literature; 4) screening for the final selection, 5) quality assessment, 6) extraction of information, 7) analyzing and synthesizing data, and 8) reporting the findings.

3.1. Formulating the Research Problem

Urban travels and understanding their dynamics and influential factors are of particular importance for planners, decision-makers, and urban managers. On the other hand, ICT has now penetrated all aspects of life, with undeniable effects on these dynamics. However, for a variety of reasons, a limited number of empirical, applied, and comprehensive studies have been conducted on the effects of these technologies on urban travel. The conceptual framework of the present study draws on the principle that information technology with direct and indirect effects on the influential factors of the urban travel pattern can thoroughly influence this pattern. Therefore, the objective of this study is to examine the empirical research on the effects of ICT on urban travels from a methodological point of view and quantitatively and qualitatively assess these studies and their findings.

3.2. Developing and validating the Review Protocol

The review protocol is partly the same as the design of research and includes the entire research process. All elements of the study should be described in the design of the research, including the purpose of the study, questions, inclusion criteria, search strategies, quality assessment criteria, screening procedures, data extraction strategies, synthesis, and review reports. The review protocol of this research has been developed by its main purpose and the review

elements have been explained in every step of the research.

3.3. Searching the Literature

The search for the related literature was carried out in three main steps: a) a list of keywords was selected, which was updated after the initial search, b) the keywords were searched on the four scientific sites Google Scholar, Science Direct Elsevier, ProQuest, and SCOPUS, and c) backward and forward search was used to obtain a complete list of literature. In the backward search, the entire list of references at the end of the article and in the forward's search, all the research that had cited the given article was searched and recorded.

3.4. Screening for Inclusion

After completing the search, all the studies were studied to decide whether to include them in the selected research list or not. Whereas it is not easy to evaluate articles based on the titles, their summaries can provide accurate information about their content (Clifford et al., 2016). Therefore, the summaries of the articles were first reviewed; then, in case of necessity, the full text was studied to screen for inclusion. After the search was completed, the findings were evaluated based on these criteria and the records that were included in the exclusion criteria were deleted.

3.5. Assessing the Quality

Any piece of writing has no scientific validity for citation. Several methods were used to evaluate recorded studies. First, their full text was reviewed and evaluated in terms of content and the scientific method. Then, according to their published date, the number of paper citations was examined. Articles that were not cited after a long time since their publication date, if they were also poorly evaluated in the full-text review, were omitted from the selection. For the final selection of the records, the journal in which the article was published was also taken into consideration. Finally, after qualitative evaluation, 77 articles were selected for the final review table 1.

After selecting the final records, a database was created in the form of a spreadsheet, in which 77 articles were recorded.

Table 1. Steps for Selecting the Articles

Steps to identify items	Main search step	After forward/ backward searches	After inclusion/ exclusion screening	After quality assessment
Number identified	178	223	112	77

3.6. Extracting the Data

By studying the full text of the research, the necessary data were extracted through the content analysis method and included in the relevant table. Content analysis is a good tool for extracting the themes and concepts of studies. Using this method, the main concepts were extracted and for ease of analysis, the data was encoded. Data extracting is a time-consuming job and should be done with great accuracy so that the results of the analysis provide a correct knowledge of the subject.

3.7. Analyzing and Synthesizing the Data

In addition to identifying and categorizing the concepts that were done using content analysis, also, the main features of the articles were analyzed through descriptive analysis and using graphs, tables, and textual descriptions.

3.8. Reporting the Findings

The results were classified and reported within the present study in a systematic process. To ease the study, the selected articles were summarized in the form of in-text citations and encoded alphabetically from 1 to 77 based on the author(s) name. Scientific

studies appear in a variety of forms, including book, dissertation, article, conference paper, report, etc. In this research, only articles published in scientific journals are selected for the review. The selected timeframe covers 2000 to 2022. Before 2000, various articles on this subject were published; but concerning the nature of the subject and given that the ICT growth was very slow before this period and its effects on urban communities have not been well-established, the data and methods used in the majority of these studies are outdated and their results could not be reliable.

Geographical Distribution: The geographical distribution of research is very considerable. About 94% of all case studies of the selected articles are related only to 10 countries. About 62% of them belonged to the United States, the Netherlands, and China (Figure 1). The United States with 22 cases, the Netherlands with 17 cases, and China with 13 case studies had the largest number of case studies. The availability of the required data or the support of the relevant institutions in these three countries may explain these large numbers. Another noteworthy point is that, despite the development of ICTs and the significant growth of their use in all countries, there have been no empirical studies on their effects on urban travel in many countries, or at least there was no article published in English in this area.

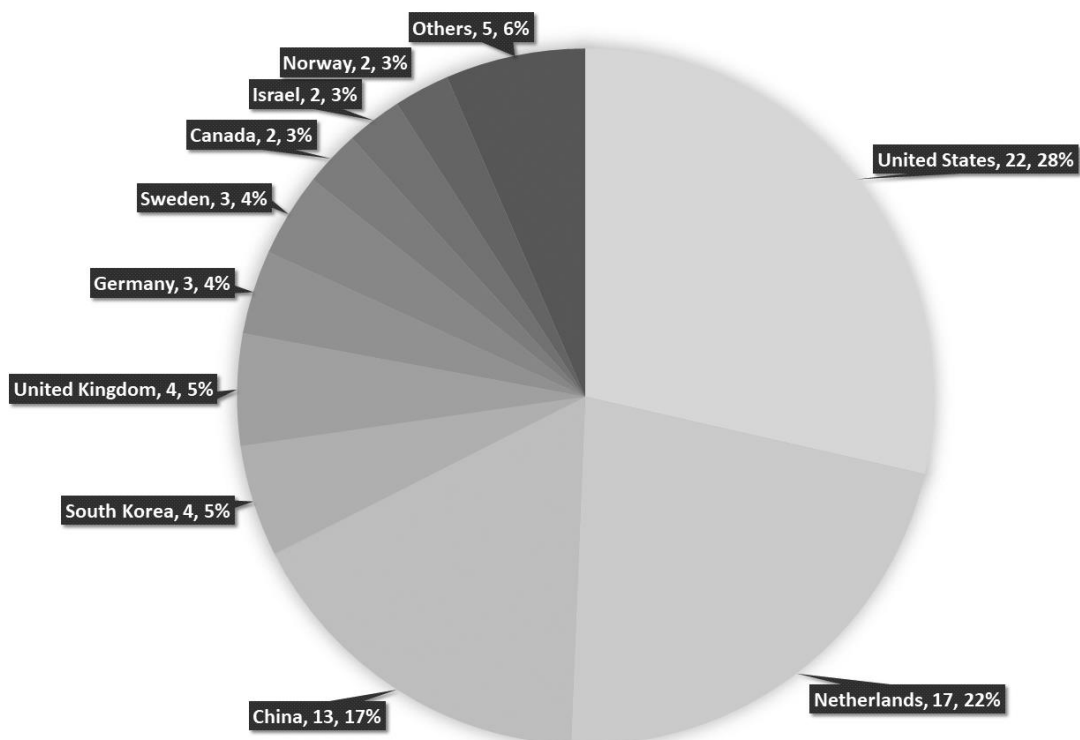


Fig 1. Geographical Distribution of Case Studies

Thematic Variation: As outlined in the theoretical framework, ICT can influence urban travel patterns by affecting the influential factors of these patterns. Therefore, the studies related to this subject have thematic variations. Here, studies are divided into 9 groups based on the central theme of the article. Figure 2 shows the frequency of articles conducted in the fields related to the given subject. As it is shown, the largest number of studies are carried out on travel and mobility, shopping, and activities. The main theme of 67% of all articles was related to these three topics. Also, the lowest share was related to accessibility, leisure, and communication issues, respectively.

The quality of research can be measured according to its impact on future studies and the quality of the journal in which it is published. For this purpose, two criteria of article's citations and journals' impact

factor have been used. The latest impact factor of the journals was taken from its main database where the journal was indexed (e.g., Elsevier, SAGE, Taylor & Francis, etc.), and the number of citations was extracted from the google scholar. The time of receiving this data was February 20, 2022. Of the total articles, 25 articles were cited more than 100 times, and the total number of citations for all 77 articles was 7420 until February 20, 2022.

The reviewed papers were published in 41 different journals. The Journal of Transport Geography with 10 papers had the largest share followed by the journals of the Transport Research Part A and Transportation Research Record each with 6 papers. The number of articles published in each journal and the impact factor of the journals are shown in Figure 3.

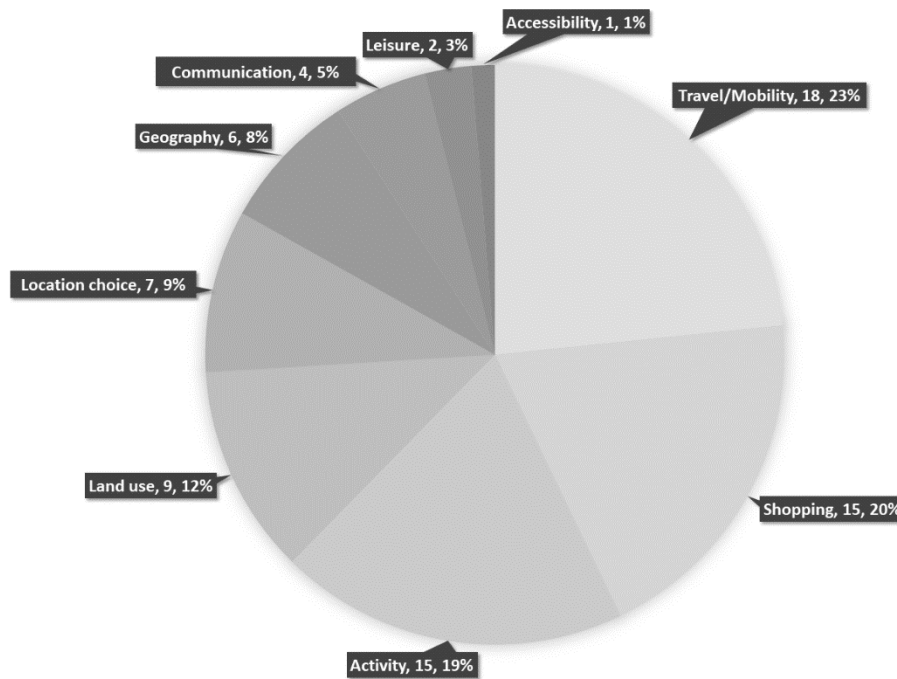


Fig 2. Thematic Variation of the Selected Articles

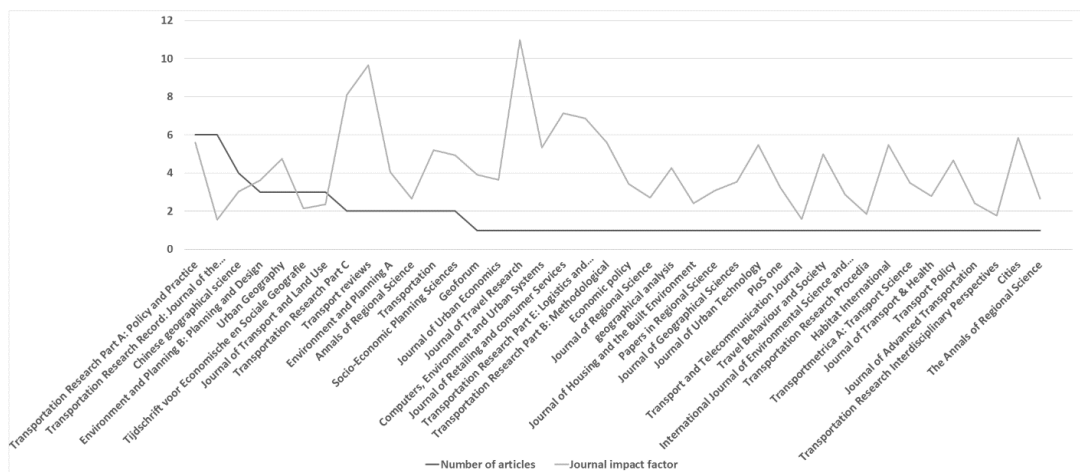


Fig 3. The Number of Articles Published in each Journal and the Impact Factor of the Journals

Methodological Analysis: Considering that the selected articles for the review were experimental with case studies, they used different approaches, data, methods, and models to answer the research questions. Only 4 papers had a qualitative approach, and the remaining 73 articles used quantitative methods for data analysis. Besides, the research can be evaluated in terms of the type of data and model(s) they employed in the research method.

The Data Used: In general, the data used in the studied research can be categorized into 5 groups:

1) Existing data: in this case, the researcher is not involved in the process of data collecting and receiving data from institutions, organizations, etc. (secondary data). Data used in 39 types of research (more than 50%) were of this type. Since the study of ICT impact on a small statistical population is not useful, the need for a large sample size has forced scholars to use large-scale and official statistics in many cases. Access to big data has paved the way for such studies in recent years.

2) Questionnaire: The data used in 16 types of research were collected through a questionnaire and their statistical population varied from tens to thousands of samples.

3) Survey: It refers to the data generated through various devices such as cell phones, GPS, sensors, etc.

and the researcher extracts the data he needs according to the needs of his study by monitoring them. In general, 13 studies used this type of data.

4) Interview: The interview is more interactive and open compared to the questionnaire and is conducted in the form of dialogue. A total of 5 studies used this method to obtain the required data.

5) Questionnaire and interview: A total of 4 studies used the combination of these methods for data collection.

Analytical Models Used: The majority of the studies with a case study and a quantitative approach and even many studies that have a qualitative approach require analytical models for extracting the findings. A lot of analytical models have been developed for various purposes and numerous computer tools and software have been designed to analyze data. The models used in the articles and the frequency of their use are shown in Figure 4.

Since many variables are involved in the relationship between ICT and urban travel patterns, the regression models, and Structural Equation Modeling (SEM) are considered efficient models for analyzing this type of data. Of 77 articles, 34 articles used regression models and 16 articles used SEM to perform data analysis.

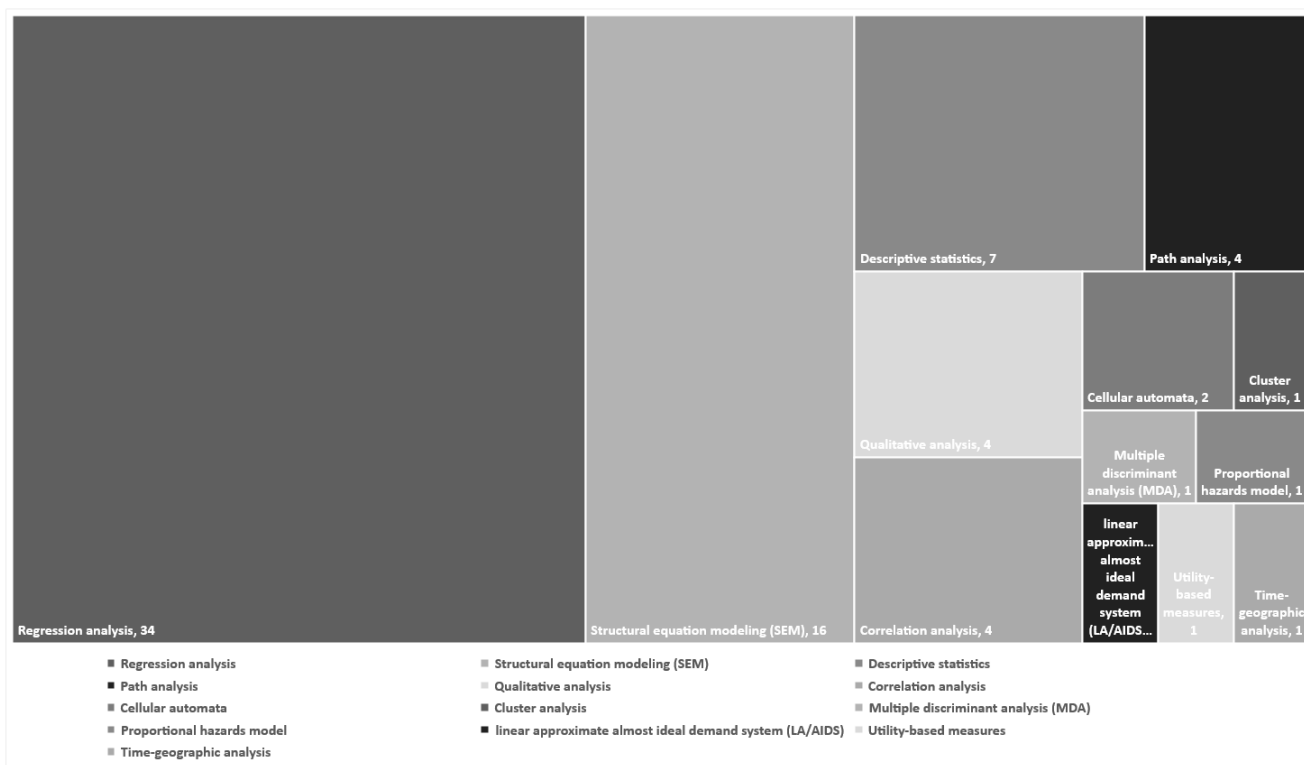


Fig 4. The Models Used in the Articles, and their Frequency of Use

4. RESULTS

The findings show that ICT can have different consequences on urban travels pattern. The implications of information and communication technology on travel-activity patterns are affected by socio-demographic, individual, spatial, and invisible characteristics of individuals (Bhat et al., 2003), and obtaining the pattern of relationship between travel and many ICT-based activities is difficult (Hjorthol & Gripsrud, 2009). However, some researchers have identified the main interactions between ICT and travel and classified the ICT implications of urban travels pattern within four main categories: substitution, complementarity, modification, and neutrality (Dijst, 2009; Mokhtarian & Meenakshisundaram, 1999). Here, based on the results obtained from the analysis of the content of the reviewed articles, the main findings of the review of the studies are classified and discussed in six groups:

4.1. Substitution-Reduction

The substitution relationship means that, through ICT, telecommuting can substitute physical activity and, subsequently, eliminate the need for the corresponding travel (Elldér, 2020). The results of some studies indicate that there is a dramatic substitution relation between teleworking and physical activity in the daily lives of people (Saxena & Mokhtarian, 1997). For instance, some researchers argue that the economic benefits of online shopping due to the omission of travel that involve time and money costs can increase the tendency to online shopping (Hsiao, 2009) and e-shopping has a substitution effect on the number of shopping trips (Shi et al., 2019). That is because the process of purchasing and delivering goods in this way is more efficient than the traditional ways of shopping (Rotem-Mindali & Salomon, 2007). ICT may also have a substitutive role in social trips while social trips play a complementary or neutral role in ICT (van den Berg et al., 2013). The findings of some studies also indicate that using mobile phones can reduce the vehicle kilometers traveled (Jamal et al., 2017; Khan et al., 2020). For example, those who live in higher mixed-use areas make fewer and shorter trips due to the use of smartphone applications (Khan et al., 2020). However, others have reported the opposite (Kong et al., 2020; Menon et al., 2020). Some conclude that the amount of these effects is not significant (Konrad & Wittowsky, 2017) or the substitution effect does not lead to a reduction in total trips. For example, with a reduction of commute travel, the saved time and cost

can stimulate demand for other types of trips (Gould & Golob, 1997; Kim, 2016). ICT can increase the number of short trips and reduce the number of long trips. In sum, it can reduce the total distance traveled (Lee et al., 2014).

4.2. Synergy-Complementary

The synergy relationship means that ICT increases physical activities, and as a result, increasing its use can lead to an increase in trips. Mitchell (1999) and Graham and Marvin (2000) predicted that the effects of interaction between information and communication technology and the automobile-dominated urban structure would increase urban trips and traffic congestion. The emergence of a new pattern of labor-based commerce has led to the formation of a "casualization of work". This form of employment may appear as self-employment, flexible working hours, part-time work, or a temporary workforce, in which most of the employees have to travel more than once a day to work in different parts of the city. Hence, this form of work can increase travel demand (Audirac, 2005).

Teleworkers record fewer commute trips, but they do more trips for other purposes (Budnitz et al., 2020). Some of the studies provide strong evidence for the reinforcing role of ICT and argue that instead of reducing the number of trips, it has increased them (Choo et al., 2007; Krizek et al., 2005; Mokhtarian & Meenakshisundaram, 1999; Mokhtarian & Salomon, 2002) and provides a complementary effect (Yuan et al., 2012; Zhang et al., 2007). Trips increase as the demand for mobile communications increases, and vice versa (Choo & Mokhtarian, 2005). The results of some studies show that ICT users spend more time traveling than others (Viswanathan et al., 2001), and those who work at home travel longer distances (Hjorthol & Gripsrud, 2009). Teleworking plays an important role in the pattern of individual travels and complements both types of business and non-business trips (Zhu, 2012). It can also increase the demand for non-vehicle trips and physical activities, in the form of hidden demand for active life (Chakrabarti, 2018).

In the case of shopping trips, the results of the most studies indicate that online shopping supplements shopping from real stores (Cao et al., 2010; Farag et al., 2006; Farag et al., 2007) and has a positive effect on this type of shopping (Ding & Lu, 2017; Van Wee et al., 2013; Zhou & Wang, 2014). Shopping in a store has a complementary rather than just hostile relationship to the frequency of online shopping, while online shopping encourages people to shop more in-store (Etminani-Ghasrodashti & Hamidi, 2020). In e-shopping for intangible services (such as

hairdressing, eating out services, and visits to movie theatres), shoppers are forced to travel to use these services (Shi et al., 2020). The results also show that people who typically shop online do more shopping trips, but their shopping time is shorter (Frag et al., 2006). Also, they use cars more than others (Hiselius et al., 2015). The results of the other studies on the relationship between ICT and face-to-face communications (Sridhar & Sridhar, 2003) and recreational activities (Lila & Anjaneyulu, 2016) reveal that ICT also has a complementary and incremental effect in these cases. It can be stated that telecommunication has a mild effect on travel because face-to-face communication is still popular and online shopping is often complemented by in-store shopping. The use of online media and documents is also often complementary to traditional media. Using the Internet may be complementary to travel-related activities (Lachapelle & Jean-Germain, 2019).

4.3. Modification

The modification relationship indicates that telecommuting alters the organization of physical activity and, as a result, changes the way people travel. For instance, teleworking is the people's solution for long and costly trips. Workers living in areas with inappropriate accessibility tend to work at home (e Silva & Melo, 2018). Teleworking undermines the link between urban structure and travel. It enables different movement strategies and leads to heterogeneous spatial travel behaviors that are mostly based on individual characteristics, rather than the relationship between work and residence. With an increase in the number of people who telework, location-based traditional models for predicting and planning transportation will be inefficient (Elldér, 2017).

ICT advancements have changed travelers' perceptions of travel distance in different ways. Teleworking has made it possible for people to work one or more days a week at home. As ICT reduces the frequency of travel, it allows the workers to accept longer distances and have more choices at hand when choosing their residence location (Ettema, 2010). On the other hand, those working in distant locations show more tendency to telecommuting (Zhou et al., 2009). Thus, when access to travel information and the possibility of teleworking are possible, negative effects and access restrictions are reduced (Lu et al., 2014). Also, the more people use ICT to carry out their work at home, the more flexible and permeable would be the boundaries between their work and family (Leung & Zhang, 2017; Qin et al., 2016; Tayyaran et al., 2003).

The results of some studies indicate that most telecommuter households live in urban suburbs. But this does not mean, however, that teleworking has facilitated settlement in the suburbs, or it does not indicate that long-distance between work and residence place encourages the residents to telecommute (Kim et al., 2012). New technological devices and applications rapidly change people's travel and communication patterns: they facilitate traveling and the better planning of activities (Line et al., 2011). ICT changes the pattern of everyday life and affects travel by bringing change to the way activities are conducted (Wang et al., 2016). Using the Internet increases the temporal flexibility of simultaneous activities as well as the spatial stability of activities (Shen et al., 2020). Sometimes, the need for transportation changes. For example, in e-commerce, the buyer can choose his product over the internet, but the seller must send the goods to the buyer (Talvitie, 2004). Also, the results show that in the context of social relations, physical movement is a precondition for the creation of virtual sharing links, and substitution of the physical trip with a virtual trip for the communications that socially do not require a continuous physical presence would only be feasible when the relationships are already formed through physical communications (Matous, 2017).

4.4. Neutrality

In a non-involvement relationship, telecommuting does not affect people's physical activity and traffic behavior. Such a relationship between ICT and urban travel is rarely present in the results of the reviewed research. Only two studies conclude that the use of ICT has no significant effect on daily trips. The researchers argue that, although there is a tendency for users of these technologies to do fewer work trips, the final effect is not significant in the total number of trips, and the spatial and temporal flexibility resulting from these technologies only distributes trips throughout the day (Hjorthol, 2002). Indeed, the long-run causal effect of ICT on commuting distance is so small that it is unrecognizable and possibly non-existent (Gubins et al., 2019).

4.5. Fragmentation of Activities

ICT causes spatial and temporal fragmentation of activities. However, its intensity depends on various factors (Alexander et al., 2010). ICT can change the rules of life by fragmenting the activities (Line et al., 2011). According to the results of the research, the relationship between the fragmentation of activity,

ICT, and travel is very complicated. Some researchers conclude that the fragmentation of activities reduces work trips but provides more opportunities for leisure and non-work trips (Ben-Elia et al., 2014). Others, in contrast, argue that fragmentation of activities may increase travel demand among ICT users (Lenz & Nobis, 2007). These consequences imply the need to reorganize individual activities in a dynamic environment (Yin et al., 2011).

4.6. Optimal Use of the Existing Transportation Systems

The results of some studies show that ICT can help the best use of existing transportation systems through using multiple modes of transportation (Astroza et al., 2017), opportunities for multi-tasking (Varghese & Jana, 2018), intelligent transportation systems (Rassia & Pardalos, 2014), and also through choosing the best route, method, and time for traveling. The results indicate that for the people who conduct multi-tasking, the value of travel time savings (VTTS) reduces (Varghese & Jana, 2018). Further use of ICT is positively and fundamentally correlated with an individual's use of ride-hailing (Kong et al., 2020). On the other hand, increased use of ICT and telecommuting will reduce the use of public transportation and increase the use of private cars (Yigitcanlar & Kamruzzaman, 2019). Nonetheless, travel distance, travel companionship, and socio-demographic characteristics (age, gender) play a decisive role in multitasking activities and the frequency of use of ICT during travel (Keseru et al., 2020).

5. CONSEQUENCES OF THE COVID-19 PANDEMIC

Covid-19 has had a significant effect on almost all aspects of people's lives around the world. This pandemic has posed serious problems and challenges for communities, especially in cities (Zhang, 2021). Implemented solutions to deal with the effects of this epidemic have changed current patterns of life and activity. Covid-19 related restrictions such as lockdowns, closure of schools and businesses, social distancing, transportation restrictions, and changing the urban travel pattern, have challenged what has been called "normal" and urges the "new normal" in human society (Alraouf, 2021; Corpuz, 2021; Emanuel et al., 2022; Jamaludin et al., 2020; Muhyiddin, 2020; Salama, 2020; Tria, 2020).

During the epidemic, people were forced to try new ways to interact, work, learn, shop, and travel

(Conway et al., 2020). The lockdowns and restrictions have led to a significant reduction in outdoor activities (de Haas et al., 2020; Fatmi, 2020) and as a result, there have been changes in the urban travel patterns. These behavioral changes in urban travel patterns may somewhat be lasting even after the Covid-19 crisis (van Wee & Witlox, 2021). Since the outbreak of Covid-19, travel restriction policies that have been widely adopted by cities around the world have played a significant role in changing urban travel patterns (Li & Zhao, 2022). The results of some studies have shown that if the Covid-19 persists, most people who do not own a car will be inclined to buy a car (Habib & Anik, 2021; Menon et al., 2020). Today, the importance and frequency of remote online activities have increased significantly due to COVID-19, especially in cities. These tendencies have contributed to changes in urban mobility (Mouratidis & Papagiannakis, 2021). National policies and local decisions against the Coronavirus have reduced the demand for motorized travel across cities (Arellana et al., 2020). However, in this "new normal" the traditional form of many activities has not undergone fundamental changes. People still have to travel to go to work, shop, and do their daily tasks (Anwari et al., 2021).

6. CONCLUSIONS AND RECOMMENDATIONS FOR THE FUTURE DIRECTIONS

A systematic review in any field requires a deep understanding of that field (Pigott, 2012). On the one hand, for a thorough understanding of scientific subjects, the relevant scientific literature should be well studied, and on the other hand, a systematic review, if it is properly carried out, can help to develop this deep understanding. "Systematicity" does not merely include classification and a systemic process: it rather expresses the quality of the review, and the quality of the reviews can be evaluated by their (not)being systematic (Okoli & Schabram, 2010). This study, through a systematic approach, examined empirical studies about the effects of ICT on urban travels. In this regard, different views on the effect and relationship of ICT with travel patterns were first outlined; then, in a systematic process, 77 types of research were selected and their various characteristics were evaluated with quantitative and qualitative analyses.

The findings of the study indicated that, first, despite the importance and extent of the subject, a small number of empirical studies have been conducted in this regard. Second, a large proportion

(about 62%) of the research focused on three countries of the United States, the Netherlands, and China. A very small share of these studies related to other countries. Third, very few studies concentrated on the direct effect of ICT on the urban travel pattern and there was almost no comprehensive study in this area. The majority of the studies focused on the implications of ICT on one of the reasons and motivations of travel (such as shopping, teleworking, leisure, etc.). Fourth, the number of citations to these articles, even to high-quality articles, has been somewhat small in comparison to the articles published on the other urban issues. This shows that the number of studies in recent years has not had a growing trend and the issue has remained less attractive to the researchers. Fifth, a large share of the studies drew on available data, notwithstanding that the type of available data cannot be adequate for analysis, given the multiple variables playing in this issue. Sixth, the lack of strong theories and theoretical views about the conceptual framework of the subject and the formulation of the problem is quite evident. Consequently, the researchers have observed the problem via their lens. Seventh, there are no suitable analytical models developed for this type of research. Although the use of regression analyses and the structural equation model can be useful according to the type of variables. Today, with the availability of big data and the huge amount of information recorded and stored by ICT devices, there is a need to develop more efficient models. This kind of data has undeniable advantages over traditional data and can pave the way for future research. Eighth, the relationship between ICT and urban travel is complex and involves multiple factors; this complexity and the multiple influential factors were often ignored. Finally, most importantly, after the Covid-19 pandemic, the use of ICT for work and activity has increased dramatically (Mouratidis & Papagiannakis, 2021).

Mobility styles are usually resistant to change under normal circumstances, but not necessarily during a long and severe pandemic (Shamshiripour et al., 2020). The covid-19 crisis may lead to structural behavioral changes (Aditantri et al., 2021; de Haas et al., 2020). During the pandemic, a significant shift has occurred from motorized to non-motorized modes of travel in the case of short-distance travel, as well as a shift from public transport to the private car for long distances (Abdullah et al., 2021; Abdullah et al., 2020). The overall number of road accidents has dropped sharply following the policy of staying home (Li & Zhao, 2022). This policy has reduced congestion, and transportation side effects (Arellana et al., 2020; Jiang et al., 2021; Loo & Huang, 2022; Rachmawati et al., 2021). Although after the

pandemic, organizations may not always allow for work-from-home on all working days of the week, there is a greater likelihood of increasing flexibility in work arrangements (Menon et al., 2020). These opportunities allow people to live further away from the city center (Habib & Anik, 2021).

ICT has paved the way for Mobility-as-a-Service as an emerging service that represents a technological innovation with the potential to revolutionize the urban mobility paradigm that creates a social shift toward more sustainable travel behaviors (Anagnostopoulou et al., 2019; Lopez-Carreiro et al., 2020; Paiva et al., 2021; Zhang et al., 2021). It is hoped that sustainable mobility will become a major issue for urban and regional mobility policies in the post-COVID-19 recovery period (Basu & Ferreira, 2021). Virtual and physical movements and the relationship between them should be taken into account in a wide range of socio-demographic factors (Konrad & Wittowsky, 2017). The effects of ICT on travel vary among groups with different socio-demographic characteristics and their location of residence (Habib & Anik, 2021; Loos et al., 2020; Maldonado Silveira Alonso Munhoz et al., 2020; Miranda-Moreno et al., 2012; Nobis & Lenz, 2009; Ozbilen et al., 2021; Ren & Kwan, 2009; Yuan et al., 2012).

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