The current issue and full text archive of this journal is available on Emerald Insight at:
https://www.emerald.com/insight/0969-9988.htm

Factors affecting the performance of construction industry during the COVID-19 pandemic: a case study in Turkey

Gulden Gumusburun Ayalp
Department of Architecture, Hasan Kalyoncu University, Gaziantep, Turkey, and
Tülay Çivici
Department of Architecture, Balikesir University, Balikesir, Turkey

Received 15 October 2021
Revised 2 February 2022
2 June 2022
10 July 2022
Accepted 21 July 2022

Abstract

Purpose – The construction industry is a crucial industry for national development worldwide. Because the construction industry is tied to national and international economic activities, the COVID-19 outbreak has limited construction projects. Therefore, this study investigates the most influential factors regarding COVID-19 and their effects on the construction industry.

Design/methodology/approach – The potential impacts of COVID-19 on the construction industry were identified through a realistic literature review and interviews with professionals. A questionnaire was distributed via e-mail to architects, civil engineers and contractors who play vital roles during the construction processes. The data were analysed using SPSS 22 and LISREL 8.7 software to quantify the most influential pandemic-related factors faced by the construction industry.

Findings – Ten influential pandemic factors affecting the construction industry in Turkey were identified. Among them, "increased costs and price escalations due to shortage of raw materials and supply chain disruption" and "challenges with payment and cash flows" were determined as the most influential pandemic factors.

Research limitations/implications – This research aims to advance comprehension of pandemic impacts and contributes an incipient assessment framework based on 10 determined pandemic factors. Therefore, contractors, architects and civil engineers may analyse their weaknesses and organise precise priorities so that their firms may remain competitive, thus minimising the adverse impact of COVID-19 and possible forthcoming waves.

Originality/value – Few studies have identified the effect of pandemics on the construction industry qualitatively, forcing management to make projections to the current situation. Moreover, no study has provided insights into the influential factors of pandemics using quantitative methods. Therefore, this study comprehensively and quantitatively determines the relevant COVID-19 pandemic factors using exploratory factor analysis (EFA) and utilises confirmatory factor analysis (CFA) and structural equation modelling to present a structural model of how pandemic factors affect the Turkish construction industry.

Keywords Construction industry, COVID-19, Pandemic factors, Structural equation modelling

Paper type Research paper

1. Introduction

The COVID-19 pandemic has elicited substantial negative responses, producing changes across all industries and professions. This unforeseen outbreak differs from previous global catastrophes due to its characteristics (Harinarain, 2020), affecting the economic system and industries and particularly affecting developing economies that have experienced a crisis and are at significant risk of producing greater losses worldwide (Franzese, 2020; Nicola *et al.*, 2020). The impact of the pandemic in industries has been among the highest (Koh, 2020; McClure *et al.*, 2020; ONS, 2020; Stiles *et al.*, 2021). COVID-19 affects human health; however, its impact is extensive to almost all aspects of life, including health, social and economic (Husien *et al.*, 2021).

Engineering, Construction and Architectural Management
© Emerald Publishing Limited
0969-9988
DOI 10.1108/ECAM-10-2021-0890

Because the construction industry is directly tied to both national and international economic activities, the current pandemic has significantly disrupted most construction sector practices. Architects and designers rapidly departed the office and began working remotely to complete the design stage, initially in Italy and then across the world (B1M, 2020; Carlson, 2020). However, to meet deadlines, a considerable on-site crew is necessary throughout the construction stage of a project. Thus, COVID-19 has had a significant influence on contractors' capacity to work on-site. Some sites were closed (PwC, 2021a), some staff were ill or were quarantined (Levelset, 2020), and payments (PwC, 2021a, b; Skyline Construction, 2020a) and material deliveries were delayed (Simmons and Simmons, 2020). All of this has led in a general shortage of funds, labour and resources (Hulme *et al.*, 2020; BEIS, 2020). All of these factors are interrelated, resulting in a cycle of delays, productivity loss and legal disputes (McKinsey and Company, 2020; BEIS, 2020; Assaad and El-Adaway, 2021a; Morris, 2020).

These problems have affected both developed and developing countries around the world. Particularly in developing countries, the construction industry is known to be a significant contributor (Asante and Mill, 2020) to the gross domestic product (GDP), which measures the volume of national output and input. In the view of Sertyeşilişik (2017), construction industries in developing countries support their economies by contributing one-third of their physical infrastructure and have a 15% share in their GDPs.

The relationship between the economic development stages of a country and the share of the construction sector in GDP was investigated by Bon (1992) and schematised as the "Bon curve" (Figure 1).

As seen in Figure 1, in low-income or underdeveloped countries, both the construction sector volume and GDP are relatively low; in developing countries, the increase in industrialisation due to the construction of infrastructure, factories, offices, housing, etc. increases the need for the construction sector to maximise its share of GDP; in high-income or developed countries, the share of the construction sector in GDP has decreased owing to decreases in housing demand resulting from low population growth rates and the fact that the infrastructure has been completed to a large extent. According to Ruddock and Lopes (2006), this is true over the long term. Construction in developed countries continues to increase, but this increase occurs at a lower rate than the growth in the economy. This view reveals that the increase in construction capacity is more important in developing countries than in developed countries (Giang and Pheng, 2011).

The construction industry represents a leading industry for national growth in the Turkish economy, providing great investment opportunities and increasing national income.

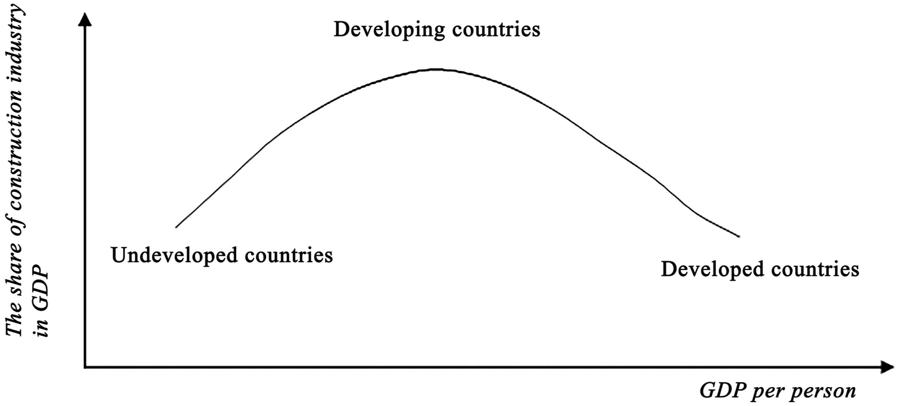

Figure 1.
Bon curve (Bon, 1992)

In Turkey, the construction industry is essentially involved in developing infrastructures such as houses, offices, bridges, dams, airports, roads, highways and power systems (Sertyeşilişik, 2017). According to the Turkish Contractor Association (2016), the construction industry's contribution to the Turkish Economy reaches up to 30%; further, the industry employs as much as 10% (excluding agriculture) of the Turkish workforce, if direct and indirect impacts on other sectors are considered. Therefore, the construction industry is a stronghold of the Turkish economy (Gürcanlı *et al.*, 2021).

Construction firms, contractors, subcontractors and consultants all play particular roles for smooth industry operation. The construction industry contributed $33 billion USD to the national GDP, with a share of 5.4% in the pre-pandemic period (Tekce, 2020). However, the construction industry is facing a 5.2% contraction due to the pandemic. Furthermore, the construction industry confidence index was 77.2% in March 2020, which decreased to 44.7 in April 2021 with the contraction in housing sales (TURKSTAT, 2021; Majumder and Biswas, 2021).

In Turkey, approximately 2.2 million people are employed in the construction industry. Thus, employment has shrunk due to the decline of this sector, where approximately 750 thousand workers became unemployed. The number of employees in the construction industry will decrease by 40.9% (TURKSTAT, 2021). To address these challenges, it is critical for the construction industry to clearly understand how the COVID-19 pandemic has affected the construction industry in developing countries.

Therefore, determining the pandemic factors affecting the construction industry over the long term is crucial. Although several studies have focused on the pandemic and construction industry worldwide (Sierra, 2022; Ayat and Kang, 2021; Majumder and Biswas, 2021; ILO Sectoral Brief, 2021; Simpeh and Amoah, 2021; Husien *et al.*, 2021; Assaad and El-Adaway, 2021a; Alsharef *et al.*, 2021; Araya, 2021; Ogunnusi *et al.*, 2022; Rehman *et al.*, 2022), no study has quantified how pandemic factors affect the construction industry of Turkey or other countries. Thus, this study identifies the major pandemic factors and their effect on the construction industry in Turkey. In this regard, the possible impacts of COVID-19 are derived from interviews and a realistic literature review. Mean score ranking was performed to determine the relative ranking of the possible impacts. Exploratory and confirmatory factor analyses were applied to establish major pandemic factors. In particular, each factor's severity was ranked using the index of relative importance. Finally, the interrelationships among the structural pandemic factors were crosschecked, establishing an integrated pandemic factor model using structural equation modelling. The developed model represents the major contribution of this study.

2. Background and research gap

This section provides a comprehensive literature review of previous studies related to COVID-19 and the construction industry. Some scholars have focused on the project delivery process (Assaad and El-adaway, 2021b; Ghandour, 2020), workforce and migrant workers (Koh, 2020; Gan and Koh, 2021), digitalisation and building information modelling (BIM) adoption (Wildenauer, 2021; Wang *et al.*, 2021) and the housing sector (Allen-Coghlan and McQuinn, 2021). Moreover, some researchers and organisations have identified the early impacts of COVID-19 on the construction industry by addressing various obstacles such as occupational health and safety challenges (Stiles *et al.*, 2021; Simpeh and Amoah, 2021; ILO Sectoral Brief, 2021; Simmons and Simmons, 2020; OSHA, 2020b), shortage of material and equipment (Alsharef *et al.*, 2021; Deloitte, 2020) and contractual complications (Ogunnusi *et al.*, 2020; Simmons and Simmons, 2020) through literature and qualitative reviews. In this context, Assaad and El-adaway (2021b) identified the current impact of COVID-19 on the construction industry and potential future research directions by reviewing the industry guidelines and best practices developed by various organisations and considering expert opinions documented in well-established resources.

Furthermore, researchers determined the early effects of the pandemic on the construction industry by reviewing the existing literature, through bibliometric analysis and by conducting semi-structured interviews (Ghandour, 2020; Alsharef *et al.*, 2021; Ayat and Kang, 2021). The perception of stakeholders in the South African construction industry was investigated during the nationwide COVID-19 shutdown (Harinarain, 2020). In addition, Simmons and Simmons (2020) reported the effects of COVID-19 on Middle Eastern construction projects.

The American Society of Civil Engineers (ASCE) conducted surveys to determine the effects of COVID-19 on the construction industry. The surveys showed that construction organisations are dealing with adverse outcomes, including delays in contracts and cancellation, delays in receiving materials from suppliers, supply chain shortages, contract penalties due to project delays, hiring freezes, cash flow challenges, absenteeism, workforce reductions, layoffs and furloughs (unpaid) (ASCE, 2020). Pricewaterhouse Coppers (PwC) (2021b) surveyed the global impact of the pandemic, and their results showed that most companies considered cost reduction in response to the pandemic and planned to cancel investments. Similarly, Deloitte (2020) stated that decreasing efficiencies, schedule delays, cost increases due to pandemic and its related regulatory responses are expected within the construction industry.

The above studies show that:

1. No previous study has determined the pandemic factors affecting the construction industry quantitatively.
2. No study identifying the most influential factors utilising COVID-19 models has been conducted in the Turkish construction industry or in construction industries of other countries.
3. Numerous stakeholders are involved in the construction processes, such as design and planning, material supply, control and construction. Therefore, the working conditions from one area to another differ in terms of the characteristics of the processes. Moreover, expecting a similar perception and impact concerning the pandemic is unrealistic. Therefore, determining the perceived differences among stakeholders, particularly for architects, civil engineers and contractors, is vital. No previous studies have focussed on the differences among construction stakeholders.
4. The abovementioned existing research has highlighted the COVID-19 impacts on different industries in various countries, but not specifically on the Turkish construction industry.

Therefore, four leading aspects represent a knowledge gap: (1) determining factors related to COVID-19 can clarify the current and potential consequences of the pandemic for the Turkish construction industry. (2) Modelling the pandemic effects may explain the significance of each factor(s) for the industry. Moreover, a modelling strategy can help implement actions to overcome the challenges faced owing to the pandemic. In particular, the model can provide insights into the relationship between factors regarding COVID-19. (3) Having information on the perception diversity of pandemic impacts among stakeholders can help manage the construction process. Finally, (4) this study addresses the research and knowledge gap by determining the COVID-related impacts on the Turkish construction industry, which can be generalised to almost all construction industries in developing countries.

3. Research design and methods

This study quantitatively identifies and assesses the impact of COVID-19 on the construction industry. In this regard, a multistage methodological framework was followed, focussing on the possible impacts related to COVID-19 on the construction industry. A questionnaire was developed for data collection and statistical analysis.

3.1 Impact of COVID-19 on the construction industry

The method followed in this study considered two main phases. In the first phase, 27 construction professionals from nine companies in Turkey were interviewed. The distribution of the interviewees was similar in terms of their profession. A wide range of interviewee ages was considered to determine the basic patterns across them. A list of construction professionals, including architects, civil engineers and contractors, was requested from the top management of each company. Subsequently, some participants were randomly selected from the list. They attended an informed consent session that lasted between 15 and 20 min. The following two open-ended questions were asked during the interviews: (1) general information about the participants, such as their roles and tenure, and (2) what are the five most important possible impacts of COVID-19 on the construction industry based on their experiences? The responses were categorised according to the type of response.

A literature review was conducted in the second phase, utilising a realistic review process. Realistic review is a theory-driven and interpretive type of literature review (Berg and Nanavati, 2016). A realist review aims to answer the question, “what works for whom in what circumstances, in what respects and how?” with respect to social intervention programs (Pawson *et al.*, 2005). Within this scope, first, the answers focussed on the following question: “What are the characteristics of this study included in the analysis?” The effect indicator was the impact of COVID-19 according to construction professionals, especially architects, civil engineers and contractors, representing significant stakeholders of the construction process.

The second stage focussed on searching and selecting seminal studies. The identification of a causal structure best explaining the phenomenon in the construction industry was conducted in electronic databases (Web of Science, Scopus and Google Scholar) considering the period from January to March 2021. The data were updated on April 2021. The following terms were used to narrow the search and choose the seminal studies: (1) regarding the population (sample): “construction professionals”, “architects”, “civil engineers” and “contractors”; (2) for context outcomes, “COVID-19 effects on construction industry” and “impacts of COVID-19 pandemic on construction industry”. Moreover, the literature review considered papers beyond those included in journal databases, including government reports, corporate documents and articles presented at seminars or symposiums. Thus, a snowball searching was performed in three additional databases, Google Scholar and Scopus.

The deadline for the realist review was April 2021. A total of 941 potential articles were found. Among them, 354 theses/dissertations or duplicates were excluded. Moreover, after reviewing the titles, 554 studies not satisfying the searching criteria were eliminated. Finally, the review focussed on 33 articles related to the impact of COVID-19 on the construction industry.

The data synthesis was the final stage of the review process. The 33 studies obtained were evaluated considering their key variables, classified into context, mechanism and outcomes. Consequently, the 59 potential impacts listed in Table 1 were determined.

3.2 Designing the measuring instrument

The second step of the method involved reviewing and analysing previous research relevant to COVID-19. Interviews were conducted using a questionnaire divided into three sections. The first section aimed to obtain data regarding the participant’s perceptions of COVID-19 impacts. Fifty-nine possible impacts were identified. Subsequently, the participants were

Table 1.
Possible impact of the COVID-19 pandemic on the construction industry

Impacts coded as	Impacts	Sources
IM1	Investing scepticism resulted in declining the volume of the construction projects	[18], [23], [34]
IM2	Declining of the clients' and investors' demands to construction projects	[23], [24], [34]
IM3	Changes in clients' demands (increased demand of detaches houses)	[23], [24], [34]
IM4	Financial uncertainties resulted in construction project investments cancellation and suspension	[2, 3], [11], [23, 24], [28], [34]
IM5	Funding restrictions and lack of financial support for construction projects (interests and financial incentives)	[2], [8], [12], [22–24], [28, 29], [34]
IM6	Cash flow and payment challenges	[2], [22], [23], [28], [34]
IM7	Facing potential contract penalties due to project delays	[2], [23], [29], [34]
IM8	Delays in payments and claims due to prolongation of project delivery time	[8], [14], [22, 23], [28, 29], [34]
IM9	Material price increments increase project costs	[2], [8], [9], [22, 23], [28, 29], [34]
IM10	Significant delays in inspections and extension of critical activities	[14], [22–24], [28, 29], [34]
IM11	Delays with building permits from various governmental agencies prolong project delivery time	[14], [12], [23, 24], [29], [34]
IM12	Revisions to the original schedule	[23], [24], [29], [34]
IM13	Reducing the number of employees in construction companies stopped hiring and recruitments	[22], [24], [28], [34]
IM14	Decrease in the employment rate due to construction volume reduction of company	[23], [24], [29], [34]
IM15	Practices to deal with absenteeism (workers who are sick, caregivers for sick family members and caregivers for children)	[2], [14], [24], [25], [29], [34]
IM16	Emerging sheltering challenges for workers working at construction sites	[24–26], [28], [34]
IM17	Migrant (workers) labourers returned to their hometown	[8], [9], [16], [22, 23], [25], [28], [34]
IM18	Increased workforce and productivity shortages due to social distance	[13], [22–24], [28], [30], [34]
IM19	Decrease in workforce due to health problems	[13], [23, 24], [34]
IM20	Forced to unpaid time off	[2], [14], [24], [29], [34]
IM21	Fear of layoff	[2], [11], [22], [24], [34]
IM22	Decrease in productivity due to the lack of necessary and sufficient hygiene conditions in the workplace/construction sites	[3], [14], [22–24], [29, 30], [34]
IM23	Delays in material supply chain and delivery	[2], [9], [11], [22, 23], [28, 29], [34]
IM24	Fear of not being able to complete the construction due to the increased cost for construction materials	[22–24], [26], [34]
IM25	Delays in warehousing for producing materials necessary for the construction	[2], [9], [23, 24], [26], [29], [34]
IM26	Challenges with international manufacturing and shipping	[2], [23–25], [34]
IM27	Shifting to prefer alternative local suppliers and manufacturers rather than foreign ones due to import delays	[23, 24], [26], [34]
IM28	Shortages of raw materials affect local suppliers negatively	[2], [5], [9], [23–25], [34]

(*continued*)

Impacts coded as	Impacts	Sources
IM29	Failure to obtain technical support for assembling building materials	[13], [23], [34]
IM30	Limited transportation and travel bans slowed project delivery and imposed challenges to equipment rental companies	[14], [20], [24], [26–28], [34]
IM31	Increased cost of imported raw construction materials at local market due to lockdown of manufacturing completely at the abroad	[2], [8], [16], [28, 29], [34]
IM32	Unavailability of construction materials due to lockdown of manufacturing completely at the abroad	[2], [23–26], [29], [34]
IM33	Unavailability of subcontractors	[1], [22–24], [30], [34]
IM34	Contracts allow extending the time of granted deadlines of project delivery time	[8], [14], [23, 24], [26], [28, 29], [34]
IM35	Investors seeking to cancel or delay the construction projects	[22–24], [34]
IM36	Increase in using "force majeure" contractual clauses	[2], [4], [8], [22–24], [29], [34]
IM37	Increase in using "relief and compensation" contractual clauses for delay-related penalties	[4], [23], [24], [34]
IM38	Contracts do not allow recovering the increased performance cost	[2], [4], [24], [28], [26], [34]
IM39	Including clauses on occupational health and safety in construction contracts	[22], [24], [34]
IM40	Delays in digitalisation investments	[15], [22–24], [30], [32], [34]
IM41	Adapting to new technologies challenges	[2], [9], [15], [21–24], [28], [30], [32], [34]
IM42	Forced to make additional investments into technology to enhance their ability to work from home efficiently	[15], [21], [23], [26], [32], [34]
IM43	Accelerating the use of integrated project delivery systems (e.g. BIM) that allow remotely managing of construction projects with the transition to working from home	[2], [9], [15], [23], [24], [29], [32], [34]
IM44	Huge spread of the COVID-19 due to collaborative structure of the construction projects	[2], [8], [19], [26], [28], [30], [34]
IM45	Lack of using personal protective equipment (mask, sanitiser)	[17], [22–24], [30], [31], [33], [34]
IM46	Lack of cleaning and disinfecting the workplace and equipment	[2], [9], [17], [19], [24], [30], [31], [34]
IM47	Lack of effective measures to prevent the virus spread	[17], [23], [30], [34]
IM48	Poor communication due to implementing social distancing and related challenges	[8], [17], [22–24], [26], [29, 30], [34]
IM49	Lack of providing social distancing rules at the workplace	[17], [23, 24], [29], [30], [34]
IM50	Several safety measures are unrealistic to adopt or are not sufficient enforced at construction workplaces	[19], [23, 24], [30], [34]
IM51	Increase in the workers' anxiety related to the safety of the construction site during the pandemic	[7], [23, 24], [30], [34]
IM52	Who should go to work (changing tasks to reduce risk)	[23], [29], [31], [34]
IM53	Obstacles to focussing on work due to working from home (more distractions at home)	[5], [9], [23], [27], [34]

(*continued*)

Table 1.

Impacts coded as	Impacts	Sources
IM54	Having to work apart from working hours due to the transition to the working from home	[5], [9], [23], [27], [34]
IM55	Increased workload (almost 16–18 h including weekends) due to working from home	[5], [9], [23], [27], [34]
IM56	No rest to leisure due to working from home	[2], [5], [9], [23], [27], [34]
IM57	Challenges balancing work-home commitments due to working from home and increased work-family conflicts	[5], [9], [23], [27], [34]
IM58	Lack of digital infrastructure for working from home (Internet outages, poor Internet quality)	[5], [9], [14], [23], [27], [34]
IM59	Physical conditions are insufficient for working from home (e.g. not available working rooms and noise at home)	[5], [9], [14], [23], [27], [34]

Note(s): [1] AGC (2020), [2] ASCE (2020), [3] Assaad and El-adaway (2020), [4] Bailey *et al.* (2020), [5] Baldwin and Mauro (2020), [6] Brown (2020), [7] Budds (2020), [8] Casady and Baxter (2020), [9] Chen *et al.* (2020), [10] Daniels and Shreve (2020), [11] ENR (2020), [12] Flyvbjerg (2020), [13] Franzese (2020), [14] Ghandour (2020), [15] Kamal (2020), [16] Koh (2020), [17] Lemke *et al.* (2020), [18] Morris (2020), [19] Okorie and Musonda (2020), [20] Viewpoint (2020), [21] Abed (2021), [22] Aladağ *et al.* (2021), [23] Alsharef *et al.* (2021), [24] Assaad and El-adaway (2021), [25] Gan and Koh (2021), [26] ILO Sectoral Brief, 2021, [27] Lingard *et al.* (2021), [28] Majumder and Biswas (2021), [29] Rehman *et al.* (2021), [30] Simpeh and Amoah (2021), [31] Stiles *et al.* (2021), [32] Wang *et al.* (2021), [33] Zheng *et al.* (2021), [34] Obtained by interviews

Table 1.

asked to rate each of the 59 COVID-19 impacts affecting their construction work according to their profession. A five-point Likert scale from 1 = never affected to 5 = completely affected was used.

The second section contained one question asked to gain insight into the participants' general perception of how the COVID-19 pandemic has affected the construction industry within the context of sector growth and productivity on a five-point Likert scale.

The participants' personal and socio-demographic information was obtained in the third section, which comprised questions focussing on gender, age, experience in the construction industry, education and profession.

3.3 Data collection process and participants

The target population for this study included architects, civil engineers and contractors in Turkey. A pilot study to determine confusing or not fully understood statements was conducted to ensure that the statements in the questionnaire were clear. Additionally, the response time of the questionnaire was determined. The pilot study involved a total of 15 participants (5 from each profession) with more than five years' experience in the field. The final questionnaire was elaborated considering the comments and suggestions from the pilot study.

The final questionnaire was distributed via e-mail to 500 construction professionals (architects, civil engineers and contractors) on 28 May 2021. The responses were accepted until 23 June 2021, and a total of 244 construction professionals submitted completed questionnaires, representing a response rate of 48.8%. The existing literature suggested that sample sizes between 100 and 400 are sufficient for structural equation modelling analysis (Molwus *et al.*, 2013). Sample size is an important issue because it relates to the stability of the parameter estimates (Schreiber *et al.*, 2006). According to Iacobucci (2009), minimum and maximum sample sizes of 50 and 100, respectively, can be sufficient and the rules of thumb suggesting required sample sizes of at least 200 are "conservative" and "simplistic". Additionally, Hair *et al.* (2008) and Oke *et al.* (2012) suggested that the appropriate sample size for SEM should be a minimum of 200 and a maximum of 400. Within this scope, a sample size of 244 in the present study can be considered sufficient. To validate and check the sample size adequacy, a power analysis was conducted using G-Power 3.1 statistical software, the results of which are reported in section 4.8.

Of the total participants, 154 (63.4%) were males. Male civil engineers outnumbered female engineers by more than three to one, and all contractors were male. This distribution is an indicator of the current condition of the Turkish construction industry, which is evidently male-dominated. Conversely, female architects significantly outnumbered male architects. Moreover, among the participating architects, civil engineers and contractors, 55.14%, 67.85% and 74.02, respectively, had bachelor's degrees. The participants' experience distribution (in years) in the construction industry is crucial for assessing the effects of COVID-19 in this sector. Most of the architects (52.72%), civil engineers (69.62%) and contractors (80.64%) had more than 10 years of experience, whereas 8.18% of architects, 3.79% of civil engineers and 7.69% of the contractors had 1–5 years of experience. Thus, an adequate level of experience was achieved.

3.4 Data analysis protocol

The survey answers were processed in the Statistical Package for Social Sciences (SPSS, v. 22.0) and LISREL (v. 8.7). In particular, a normality test, reliability analysis, mean score ranking analysis, one-way ANOVA, exploratory factor analysis (EFA), confirmatory factor analysis (CFA) and structural equation modelling were performed.

Reliability analysis was performed to evaluate the internal consistency among questions in the questionnaire (Nunnally and Bernstein, 2007). The Likert-scale questions were used in the first part of the questionnaire; thus, Cronbach's alpha (α) coefficient was calculated to evaluate the reliability and validity of the responses. The α coefficient value range is 0–1. As a generally accepted rule, a Cronbach's alpha of 0.7 indicates an acceptable level of reliability (Cronbach, 1951; Tavakol and Dennick, 2011).

After the reliability test, mean score-ranking analysis was used to rank the identified 59 impacts of COVID-19 for the construction industry and determine the critical pandemic impact (CPI). CPI is a technique that uses normalised mean scores >0.50 for each variable (variables are COVID-19 impacts for this study) (King *et al.*, 2022). Many researchers employ this technique to determine critical success factors for design-build implementations (Lee *et al.*, 2021) and affordable housing (Adabre *et al.*, 2020). A total of 244 participant responses were analysed using SPSS 22.0 to obtain the mean and standard deviation. Subsequently, the min–max normalisation method was used. Each column of the dataset was normalised to the interval (0, 1) to identify the mentioned impacts ranked as the most critical impacts of the pandemic.

The Shapiro–Wilk test was performed to verify the distribution of the dataset (Chou *et al.*, 1998). The test allows identifying whether nonparametric or parametric statistical analysis can be applied to the dataset. Moreover, one-way ANOVA was used to compare the means of different populations (Hesamian, 2016).

To identify the underlying factors affecting the construction industry, participants' responses related to the 59 COVID-19 impacts were analysed in SPSS through EFA. In particular, the varimax rotation (eigenvalue 1 cut-off) was used to identify significance. The primary objective of EFA is to limit the number of variables based on the minimum information loss. Moreover, EFA detects the structure of the relationships between those variables (Hair *et al.*, 1992). For example, factors having a factor loading higher than 0.4 are considered major influential factors (Nunnally and Bernstein, 2007).

The index of relative importance (IRI) was used to classify the participants' responses regarding the perception level of how COVID-19 affects the construction industry. The IRI is calculated as follows (Zhao and Chen, 2018):

$$IRI_k(\%) = \frac{5(n_5) + 4(n_4) + 3(n_3) + 2(n_2) + n_1}{5(n_5 + n_4 + n_3 + n_2 + n_1)} \times 100 \tag{1}$$

where IRI_k (%) represents the perception of possible COVID-19 impacts and is evaluated individually for regarding data (k) of respondents. In the equation, k specifies the level of effect.

The overall IRI for each impact considering all participants was determined for all sets of the effect levels using the weighted average of the IRI_k, as follows (El-Gohary and Aziz, 2014):

$$Overall\ IRI\ (\%) = \frac{\sum_{k=1}^{k=5}(k \times IRI_k)}{\sum_{k=1}^{k=5}k} \times 100 \tag{2}$$

Where, *Overall IRI* (%) represents the total weighted average percentage of the IRI for each impact. Furthermore, *Overall IRI* (%) was calculated by relying on all sets of participant levels of affection. $\mathrm{IRI_k}$ is calculated separately from Eq. (1), and the factor index was determined using the average IRI of the items for each factor.

Subsequently, a CFA was performed on the factors determined by EFA, using LISREL. Specifically, CFA allowed establishing the relationships between the observed measures (e.g. test items, test scores and behavioural observation ratings) and factors or the latent variables (Brown and Moore, 2012).

To identify the importance and severity of COVID-19 influential factors quantitatively, a structural equation model (SEM) was set up using LISREL as a final step. The mentioned analysis provides an opportunity to confirm the sufficiency of the model concerning the relationship between measurement paths and latent variables. While there are several outlooks for the adequacy of path coefficients above the 0.1 threshold, a path coefficient of 0.2 is recommended (Chin, 1998). The higher the path coefficient, the stronger the relationship between the independent and dependent constructs of a path (Lohmöller, 1989).

4. Results

This study follows a multistage and comprehensive methodological framework to ascertain pandemic factors affecting the construction industry. Figure 2 illustrates the overall framework for the current research.

4.1 Reliability and validity of the questionnaire

An adequate internal consistency of the responses was obtained ($\alpha = 0.971$, above the minimum threshold of 0.7) (Tavakol and Dennick, 2011).

4.2 Normality test

Among the study participants, before performing statistical tests, the Shapiro–Wilk test showed that the data set was normally distributed, with p-values higher than 0.05 (95% confidence level) for all items (Table 2). Therefore, parametric analyses were performed to examine the differences between each professional group.

4.3 Frequently experienced COVID-19 impacts on the construction industry—critical pandemic impacts

The mean, normalised values and rank orders of the identified 59 impacts obtained in previous sections were used to establish the significance levels; the ranking analysis results of COVID-19 impacts are listed in Table 2.

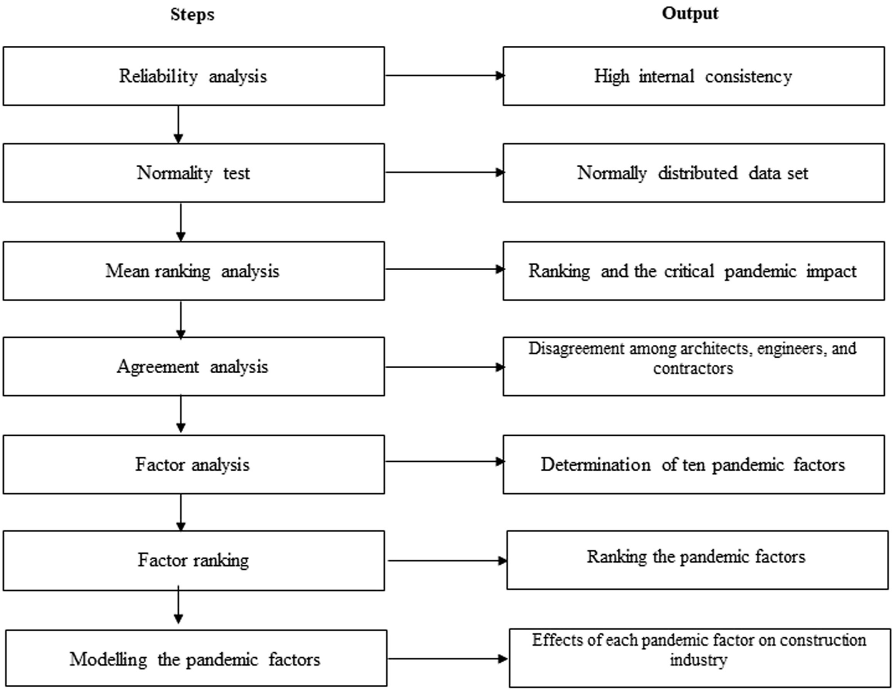

Figure 2. Result framework for the study

When two or more impacts had similar mean scores, the impact presenting the lower standard deviation was ranked the highest. A smaller standard deviation (SD) suggests smaller differences between responses and a mean that is more likely to be valid (Staplehurst and Ragsdell, 2010). The 59 possible impacts range from 4.49 to 3.19 for architects, 4.67 to 3.32 for civil engineers, 4.89 to 2.81 for contractors and 4.64 to 3.25 for all samples. Impacts with normalised mean values of 0.50 or greater are identified as CPIs. Sixteen of the 59 impacts showed mean values of 0.50 or above; among these, increased project costs due to material price increments (IM9), fear of not being able to complete construction due to increased cost for materials (IM24), increased cost of imported raw materials (IM31), cash flow and payment challenges (IM6), and funding restrictions and lack of financial support (IM5) (see Table 2) were the top five critical impacts.

4.4 Perceived importance of the COVID-19 effects among participants profession

Three groups were considered in the analysis: “architects”, “civil engineers” and “contractors”. Each participant was asked to rate each COVID-19 related impacts in terms of importance and relevance. Based on the results of the previous section, a one-way ANOVA test was performed on the mean scores of the dependent variable (59 items) to explore divergences among the different groups. In addition, Levene’s test to check for homogeneity of variances was performed, and the test assumption that the variances in the three class groups are equal for each of the dependent variables was supported. A significant level of 5% was considered. Moreover, to reduce the chance of obtaining false-positive results, the Bonferroni correction was used. The Bonferroni method reduces the critical significance level according to the number of independent variables utilised in the study. As there were three

Table 2.
COVID-19 related items affecting construction industry (n = 244)

						Profession									
		All respondents (architects, civil engineers, contractors)				Architects' response (n = 113)			Civil engineers' response (n = 82)			Contractors' response (n = 49)			
Codes of impacts	Shapiro–Wilk test (sig.)	Mean ($\overline{X}$)	SD	NV	*Rank*	Mean ($\overline{X}$)	NV	*Rank*	Mean ($\overline{X}$)	NV	*Rank*	Mean ($\overline{X}$)	NV	*Rank*	One-way ANOVA test sig. (p-value)
IM1	0.06	3.69	0.991	0.32	*45*	3.35	0.12	*56*	4.03	0.52	*17*	3.94	0.54	*26*	$0.00^{a,\ b}$
IM2	0.05	3.79	0.970	0.39	*30*	3.47	0.22	*49*	4.04	0.53	*16*	3.98	0.56	*23*	$0.00^{a,\ b}$
IM3	0.06	3.91	1.008	0.47	*20*	3.77	0.45	*28*	3.84	0.38	*29*	4.38	0.76	*4*	$0.00^{b,\ c}$
IM4	0.07	4.08	0.946	0.60	*7*	4.07	0.68	*7*	4.03	0.52	*19*	4.13	0.63	*13*	0.84
IM5	0.06	4.12	0.958	0.63	*5*	4.03	0.65	*9*	4.13	0.60	*9*	4.21	0.67	*9*	0.51
IM6	0.06	4.21	0.901	0.69	*4*	3.97	0.60	*12*	4.34	0.76	*2*	4.43	0.78	*3*	$0.00^{a,\ b}$
IM7	0.07	3.56	1.048	0.22	*53*	3.32	0.10	*58*	3.63	0.23	*50*	3.87	0.51	*28*	0.00^{b}
IM8	0.07	4.06	0.932	0.58	*9*	3.89	0.54	*17*	4.20	0.65	*6*	4.15	0.64	*12*	0.06
IM9	0.09	4.64	0.727	1.00	*1*	4.49	1.00	*1*	4.67	1.00	*1*	4.89	1.00	*1*	0.00^{b}
IM10	0.07	3.56	0.962	0.22	*52*	3.46	0.21	*50*	3.52	0.15	*55*	3.72	0.44	*31*	0.29
IM11	0.06	3.90	1.003	0.47	*19*	3.75	0.43	*33*	3.92	0.45	*25*	4.11	0.62	*14*	0.12
IM12	0.10	3.95	0.887	0.50	*14*	3.83	0.49	*23*	3.94	0.46	*24*	4.21	0.67	*7*	0.04
IM13	0.08	3.75	1.066	0.36	*37*	3.52	0.25	*48*	4.10	0.58	*11*	3.64	0.40	*39*	$0.00^{a,\ c}$
IM14	0.05	3.95	0.957	0.50	*16*	3.70	0.39	*37*	4.24	0.68	*5*	4.00	0.57	*17*	0.00^{a}
IM15	0.10	3.99	0.886	0.53	*11*	3.83	0.49	*25*	4.06	0.55	*14*	4.21	0.67	*7*	0.02
IM16	0.13	3.58	1.015	0.24	*51*	3.52	0.25	*47*	3.76	0.33	*38*	3.30	0.23	*56*	0.04
IM17	0.06	3.25	1.101	0.00	*59*	3.19	0.00	*59*	3.56	0.18	*54*	2.81	0.00	*59*	0.00^{c}
IM18	0.08	3.76	0.945	0.37	*35*	3.64	0.35	*40*	3.76	0.33	*36*	4.00	0.57	*19*	0.09
IM19	0.07	3.83	0.981	0.42	*28*	3.62	0.33	*43*	4.03	0.52	*20*	3.96	0.55	*24*	0.01^{a}
IM20	0.09	3.70	1.027	0.32	*47*	3.43	0.18	*52*	4.19	0.64	*7*	3.51	0.34	*47*	$0.00^{a,\ c}$
IM21	0.06	3.77	1.050	0.37	*36*	3.56	0.28	*46*	4.10	0.58	*10*	3.66	0.41	*36*	0.00^{a}
IM22	0.06	3.58	0.998	0.24	*50*	3.55	0.28	*45*	3.68	0.27	*46*	3.43	0.30	*49*	0.36
IM23	0.11	3.97	0.970	0.52	*13*	3.83	0.49	*26*	4.09	0.57	*12*	4.04	0.59	*16*	0.15
IM24	0.07	4.37	0.883	0.81	*2*	4.35	0.89	*2*	4.28	0.71	*4*	4.49	0.81	*2*	0.43
IM25	0.12	4.09	0.889	0.60	*6*	4.03	0.65	*10*	4.08	0.56	*13*	4.26	0.69	*6*	0.34
IM26	0.12	4.09	0.960	0.60	*8*	3.98	0.61	*11*	4.14	0.61	*8*	4.19	0.66	*10*	0.35
IM27	0.08	3.72	0.925	0.34	*39*	3.64	0.35	*41*	3.89	0.42	*27*	3.57	0.37	*42*	0.10
IM28	0.06	3.95	0.926	0.50	*15*	3.85	0.51	*21*	4.05	0.54	*15*	4.00	0.57	*20*	0.30
IM29	0.09	3.54	0.945	0.21	*54*	3.45	0.20	*51*	3.56	0.18	*53*	3.64	0.40	*37*	0.50
IM30	0.10	3.78	0.996	0.38	*32*	3.77	0.45	*28*	3.65	0.24	*49*	3.94	0.54	*25*	0.28
IM31	0.10	4.25	0.875	0.72	*3*	4.14	0.73	*5*	4.33	0.75	*3*	4.32	0.73	*5*	0.26

(*continued*)

Table 2.

		Profession All respondents (architects, civil engineers, contractors)				Architects' response (n = 113)			Civil engineers' response (n = 82)			Contractors' response (n = 49)			
Codes of impacts	Shapiro–Wilk test (sig.)	Mean ($\overline{X}$)	SD	NV	*Rank*	Mean ($\overline{X}$)	NV	*Rank*	Mean ($\overline{X}$)	NV	*Rank*	Mean ($\overline{X}$)	NV	*Rank*	One-way ANOVA test sig. (p-value)
IM32	0.12	3.98	0.909	0.53	*12*	3.95	0.58	*13*	4.01	0.51	*21*	3.98	0.56	*22*	0.91
IM33	0.13	3.87	0.911	0.45	*23*	3.87	0.52	*18*	3.81	0.36	*30*	4.00	0.57	*18*	0.53
IM34	0.13	3.91	0.830	0.47	*17*	3.83	0.49	*23*	3.99	0.49	*22*	3.87	0.51	*27*	0.42
IM35	0.06	3.84	0.902	0.42	*26*	3.76	0.44	*30*	3.94	0.46	*23*	3.81	0.48	*29*	0.42
IM36	0.06	3.78	0.908	0.38	*31*	3.69	0.38	*38*	3.91	0.44	*26*	3.79	0.47	*30*	0.26
IM37	0.06	3.71	0.891	0.33	*40*	3.71	0.40	*36*	3.71	0.29	*41*	3.70	0.43	*32*	0.99
IM38	0.14	4.02	0.895	0.55	*10*	3.95	0.58	*13*	4.03	0.52	*18*	4.15	0.64	*11*	0.45
IM39	0.27	3.78	0.948	0.45	*24*	3.73	0.42	*35*	3.71	0.29	*42*	3.98	0.56	*21*	0.25
IM40	0.06	3.41	0.964	0.12	*58*	3.38	0.15	*55*	3.47	0.11	*56*	3.28	0.22	*58*	0.55
IM41	0.08	3.44	0.949	0.14	*55*	3.40	0.16	*53*	3.41	0.06	*58*	3.55	0.36	*44*	0.62
IM42	0.08	3.44	0.975	0.14	*56*	3.35	0.12	*57*	3.42	0.07	*57*	3.57	0.37	*41*	0.43
IM43	0.09	3.43	0.961	0.13	*57*	3.39	0.15	*54*	3.32	0.00	*59*	3.64	0.40	*38*	0.18
IM44	0.07	3.89	0.861	0.46	*21*	3.92	0.56	*16*	3.73	0.31	*39*	4.04	0.59	*15*	0.12
IM45	0.12	3.70	1.002	0.32	*46*	3.84	0.50	*22*	3.67	0.26	*47*	3.36	0.27	*52*	0.02
IM46	0.12	3.71	0.988	0.33	*43*	3.81	0.48	*27*	3.63	0.23	*52*	3.53	0.35	*46*	0.22
IM47	0.08	3.81	0.979	0.40	*29*	3.95	0.58	*13*	3.68	0.27	*45*	3.57	0.37	*43*	0.06
IM48	0.08	3.63	0.993	0.27	*49*	3.57	0.29	*44*	3.80	0.35	*32*	3.40	0.29	*51*	0.08
IM49	0.06	3.78	0.935	0.38	*33*	3.85	0.51	*20*	3.78	0.34	*35*	3.55	0.36	*45*	0.18
IM50	0.23	3.71	0.896	0.33	*41*	3.74	0.42	*34*	3.65	0.24	*48*	3.66	0.41	*35*	0.76
IM51	0.06	3.71	0.910	0.33	*42*	3.63	0.34	*42*	3.80	0.35	*34*	3.68	0.42	*34*	0.45
IM52	0.10	3.70	0.916	0.32	*44*	3.75	0.43	*32*	3.68	0.27	*44*	3.47	0.32	*48*	0.21
IM53	0.11	3.77	0.879	0.37	*34*	3.75	0.43	*31*	3.80	0.35	*31*	3.70	0.43	*33*	0.84
IM54	0.09	3.90	0.993	0.47	*18*	4.21	0.78	*3*	3.70	0.28	*43*	3.40	0.29	*50*	0.00$^{a, b}$
IM55	0.08	3.89	1.011	0.46	*22*	4.16	0.75	*4*	3.80	0.35	*32*	3.30	0.23	*57*	0.00$^{a, b, c}$
IM56	0.06	3.86	0.969	0.44	*25*	4.08	0.68	*8*	3.85	0.39	*28*	3.32	0.24	*54*	0.00$^{b, c}$
IM57	0.08	3.83	0.945	0.42	*27*	4.10	0.70	*6*	3.76	0.33	*36*	3.34	0.26	*53*	0.00$^{a, b, c}$
IM58	0.07	3.73	0.957	0.35	*38*	3.87	0.52	*19*	3.72	0.30	*40*	3.30	0.23	*55*	0.00^{b,c}
IM59	0.06	3.66	0.954	0.29	*48*	3.69	0.38	*39*	3.63	0.23	*51*	3.57	0.37	*40*	0.77

Note(s): SD = standard deviation; NV = normalised value = (mean−minimum mean)/(maximum mean/minimum mean); [a]Significant difference between mean architect and civil engineer responses; [b]Significant difference between mean architect and contractor responses; [c]Significant difference between mean civil engineer and contractor response groups (multiple independent variables), the Bonferroni correction was calculated as $\alpha = 0.05/3 = 0.016$. Table 2 lists the results of the ANOVA test.

Forty-two of fifty-nine items showed significance levels higher than the adjusted α level of 0.016. The results imply a consistent opinion among architects, civil engineers and contractors. Nevertheless, the perceptions of the three respondent groups were different for 17 items (*IM1-IM3, IM6, IM7, IM9, IM13, IM14, IM17, IM19-IM21 and IM54-IM58*) that have a significance level of less than 0.016. Thus, a Tukey post-hoc test was performed to evaluate which groups differed and to categorise their differences (Appendix). Three significant-group differences are present, particularly in the “architect vs civil engineer”, “architect vs contractor” and “civil engineers vs contractor” groups.

Civil engineers and contractors provided higher mean responses than architects for *IM1, IM2 and IM6*. Thus, these effects were more important and influential to both civil engineers and contractors than architects (Table 2).

Contractors paid significantly more attention than civil engineers and architects to the impact *IM3*. Therefore, this impact was perceived as more relevant to contractors than to civil engineers and architects. Moreover, contractors perceived *IM7* and *IM9* as more relevant than architects (Table 2).

Civil engineers provided higher mean responses than contractors and architects for *IM13* and *IM20*. Additionally, civil engineers paid significant attention to the impacts *IM14, IM19 and IM21* compared to architects and more attention than contractors to *IM17*. Therefore, these impacts were more relevant to civil engineers than to other groups.

Table 2 shows that architects provide higher mean responses than contractors and civil engineers for *IM54,* demonstrating that this impact is more influential for architects. Moreover, *IM56* and *IM58* were perceived as more influential by architects and civil engineers than by contractors.

Finally, architects paid significantly more attention than civil engineers and contractors to *IM55* and *IM57*. These two items were more influential for civil engineers than contractors. Although different groups expressed different opinions for the impacts mentioned above and ranked them differently, they formed a consensus on *IM9*, which was ranked first for each group (Table 2).

4.5 Underlying factors affecting the construction industry

The principal component extraction method was applied for EFA, particularly the varimax with Kaiser normalisation of rotation, to mathematically define a relatively small number of variables providing the most information on how the 59 COVID-19 impacts affected the construction industry.

Table 3 presents the results of EFA. All items were loaded into appropriate factors (Table 2) because they all showed factor loadings higher than 0.4. Moreover, the Kaiser–Meyer–Olkin (KMO) value for sampling adequacy was 0.846, which was higher than 0.5, implying that factor analysis can be applied to the dataset (Pallant, 2005). Furthermore, Bartlett’s sphericity test indicated a significance of 0.000, suggesting that the population correlation matrix did not correspond to an identity matrix. Thus, factors having an eigenvalue higher than 1 were selected, with a total of ten components, accounting for 77.004% of the explained total variance. Subsequently, these components were interpreted, labelled and coded as follows:

Factor 1: Increased costs and price escalations due to limited raw materials and supply chain disruption (ICPE)

Factor 2: Unsafe working conditions regarding virus spread in the workplace (UWC)

Factor 3: Increased workload, work-home conflict due to transition working from home (IWHC)

Table 3. Exploratory, confirmatory factor analysis and IRI analysis results

	Exploratory factor analyse and IRI analyse							Confirmatory factor analyse
Factor	Impacts coded as	Factor loadings	Overall IRI	Average IRI (%)	Rank of factor	% of variance	Cronbach alpha	Standardised coefficients (CFA)
Factor 1-ICPE	IM28	0.758	74.08	76.49	1	14.414	0.934	0.79
	IM32	0.757	75.72					0.72
	IM26	0.747	77.04					0.81
	IM31	0.723	79.94					0.65
	IM24	0.663	82.64					0.72
	IM25	0.649	79.40					0.69
	IM27	0.637	70.20					0.68
	IM23	0.591	75.37					0.71
	IM33	0.562	73.28					0.62
	IM29	0.525	65.95					0.66
	IM35	0.488	74.18					0.55
	IM9	0.476	90.11					0.50
Factor 2-UWC	IM46	0.829	70.73	70.99	7	11.508	0.932	0.82
	IM47	0.824	72.94					0.90
	IM49	0.800	71.66					0.78
	IM45	0.792	71.53					0.82
	IM50	0.714	69.53					0.71
	IM51	0.676	70.61					0.68
	IM48	0.536	67.30					0.70
	IM52	0.529	71.33					0.60
	IM22	0.491	69.94					0.63
	IM44	0.490	74.34					0.55
Factor 3-IWHC	IM56	0.845	75.32	73.63	4	10.578	0.937	0.86
	IM54	0.843	73.85					0.89
	IM55	0.839	74.68					0.90
	IM53	0.740	75.34					0.61
	IM57	0.697	73.32					0.77
	IM58	0.691	71.55					0.78
	IM59	0.658	71.38					0.73
Factor 4-CPCF	IM8	0.736	78.32	73.44	5	9.087	0.893	0.71
	IM7	0.686	66.33					0.67
	IM15	0.659	76.37					0.69
	IM12	0.649	75.12					0.72
	IM13	0.592	70.05					0.86
	IM14	0.549	74.46					0.76
Factor 5-DPSDNP	IM2	0.803	71.62	75.38	2	6.510	0.854	0.63
	IM1	0.786	71.22					0.55
	IM5	0.542	77.03					0.83
	IM4	0.506	81.79					0.78
	IM6	0.482	77.01					0.72
	IM3	0.404	73.63					0.50
Factor 6-CRW	IM20	0.811	73.20	69.41	9	5.785	0.819	0.56
	IM21	0.773	74.06					0.61
	IM17	0.551	63.20					0.96
	IM16	0.440	67.18					0.85
Factor 7- CANT	IM41	0.777	68.75	67.47	10	5.702	0.864	0.85
	IM42	0.739	66.23					0.74
	IM40	0.680	66.08					0.80
	IM43	0.530	68.85					0.62

(*continued*)

Table 3.

Factor	Exploratory factor analyse and IRI analyse							Confirmatory factor analyse
	Impacts coded as	Factor loadings	Overall IRI	Average IRI (%)	Rank of factor	% of variance	Cronbach alpha	Standardised coefficients (CFA)
Factor 8-REP	IM18	0.684	74.84	73.31	6	4.962	0.774	0.62
	IM30	0.605	71.39					0.69
	IM19	0.543	73.72					0.83
Factor 9- IDC	IM34	0.660	76.43	74.41	3	4.879	0.831	0.58
	IM39	0.610	74.56					0.50
	IM38	0.558	77.98					0.69
	IM36	0.555	73.75					0.73
	IM37	0.500	69.37					0.71
Factor 10-DICP	IM10	0.666	69.69	70.69	8	3.578	0.743	0.58
	IM11	0.587	71.69					0.79
Total explained variance						*77.004*	χ^2/df	*2.96*
Kaiser–Meyer–Olkin (KMO) value						*0.846*	*RMSEA*	*0.04*
Barlett's test of sphericity	*Approx. chi-square*					*15668.384*	*CFI*	*0.97*
	df					*1711*	*GFI*	*0.97*
	p					*0.000*	*AGFI*	*0.95*

Factor 4: Challenges in payment and cash flows (CPCF)

Factor 5: Deceleration of ongoing projects or suspension and delay in the starting day for new projects (DPSDNP)

Factor 6: Challenges due to reduced workforce (CRW)

Factor 7: Challenges in adapting to new technologies (CANT)

Factor 8: Reduction in efficiency and productivity (REP)

Factor 9: Increase in disputes and claims (IDC)

Factor 10: Delays in inspections and construction permits (DICP)

Table 3 lists the EFA results of the 59 items with their Cronbach's alpha coefficient in the range of 0.934–0.743 ($\alpha > 0.600$). The results indicate adequate scale reliability.

4.6 Results of factor ranking

A factor model considering the ten factors obtained in the previous section was developed. IRI analysis was implemented to rank the relative importance of each factor, as shown in Table 3. The relevance of each factor decreases in the order ICPE, DPSDNP, IDC, IWHC, CPCF, REP, UWC, DICP, CRW and CANT (from 76.49% to 67.47% IRI average). Consequently, ICPE showed the most significant impact related to COVID-19 on the construction industry in Turkey.

4.7 Confirmatory factor analysis (CFA)

Table 3 lists the CFA results, where all standardised coefficients are equal to or higher than 0.5. The goodness of fit (GOF) was proposed to evaluate the model. The results were satisfactory as a value of $\chi^2/\mathrm{df} = 2.96 < 3.00$ was obtained. Moreover, the comparative fit index (CFI) was 0.97, the root mean square error of approximation (RMSEA) was 0.04, and the goodness of fit index (GFI) was 0.97. These results indicate a good model fit. The fitness ratios of the model confidently indicate that the CFA model fits well. Thus, the model allows verifying the measurement scales. Consequently, all impacts and factors contained in the hypothetical model were considered reliable, and SEM was used to test the theoretical model.

4.8 Structural equation modelling

An integrated SEM was created in LISREL. Figure 3 shows the conceptual model developed based on related literature and interviews. Each path of the model presents a hypothetical relationship between a pair of constructs.

Here, the hypothesis that factors ICPE, UWC, IWHC, CPCF, DPSDNP, CRW, CANT, REP, IDC and DICP affected the construction industry was considered. Therefore, the following ten hypotheses were established (paths in Figure 3) to investigate the main effects of these factors.

H1. ICPE has a direct effect on the construction industry.

H2. UWC has a direct effect on the construction industry.

H3. IWHC has a direct effect on the construction industry.

H4. CPCF has a direct effect on the construction industry.

H5. DPSDNP has a direct effect on the construction industry.

H6. CRW has a direct effect on the construction industry.

H7. CANT has a direct effect on the construction industry.

H8. REP has a direct effect on the construction industry.

H9. IDC has a direct effect on the construction industry.

H10. DICP has a direct effect on the construction industry.

A power analysis ($1-\beta$) test was used to check the stability of the model's parameters with the sample size used for the analysis. First, the minimum sample size was calculated by G-Power 3.1. As input parameters, a significance level of 0.01 (99% of confidence level) was

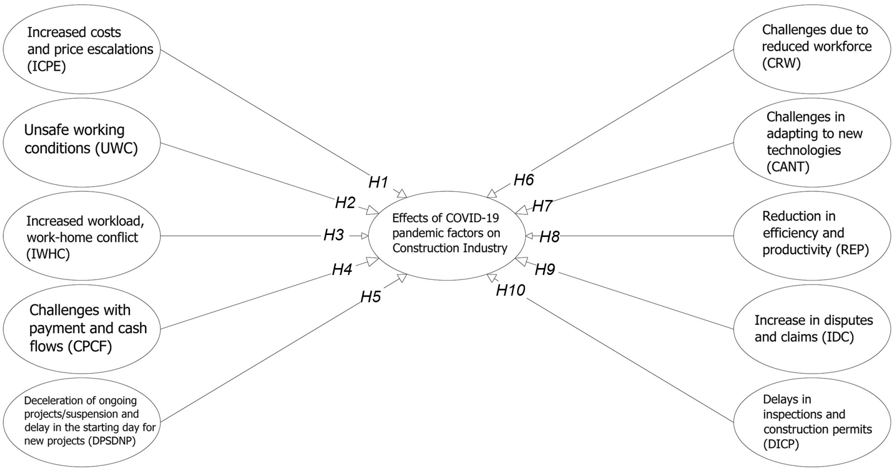

Figure 3.
Hypothetical model of factors affecting the construction industry during COVID-19

used, and an effect size (f^2) of 0.35 was used for large effect (Hair *et al.*, 2017; Cohen, 1988); the number of predictors was set to 10 (latent variables). In the power analysis, the minimum sample size was calculated as 127, and actual power was determined as 0.990 (Figure 4). The calculated power values for the developed model using G-Power are shown in Figure 4.

Figure 4 indicates that the power of the overall model increases as the sample size increases. A power of 100% is achieved with a sample size of 127. The sample size in this study is 244. Therefore, it is clear that the sample size used in this study is adequate for achieving substantial power and that the structural model reached an acceptable estimate level for model validity.

Regarding the hypothetical model (Figure 3), a final SEM was developed (Figure 5) that presents the standardised path coefficients of each hypothesis. The model was assessed based on GOF measures, *t*-value test and path coefficient values (sizes and statistical significance). Tables 4 and 5 list the parameters considered for model validation.

The developed SEM has a high level of fitness, also seen in Table 4. Therefore, relying on the required GOF measures, the model was considered satisfactory. Table 5 lists the hypothetical paths and the impacts assumed.

Figure 5 and Table 5 indicate that all hypotheses were verified ($p < 0.01$, *t*-values >2.58). Thus, all factors affect the construction industry negatively. Although they were all significant, ICPE, CPCF, IDC, DICP, REP and DPSDNP were the most influential.

5. Discussion

This study examines the factors related to COVID-19 affecting the Turkish construction industry. The findings in literature on this topic are limited to a general overview. Consequently, identifying and understanding the most relevant factors of COVID-19 affecting the construction industry is crucial.

5.1 Impacts of COVID-19 on the construction industry

As shown in Table 2, the following three CPIs are the most relevant: Increased project costs due to material price increments, fear of not being able to complete the construction due to increased cost for construction materials and increased cost of imported raw construction

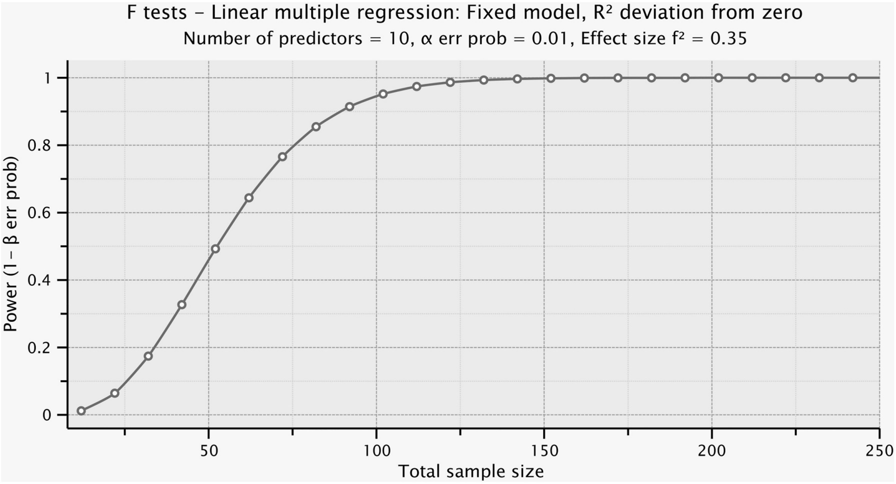

Figure 4.
Measurement model for impacts of pandemic

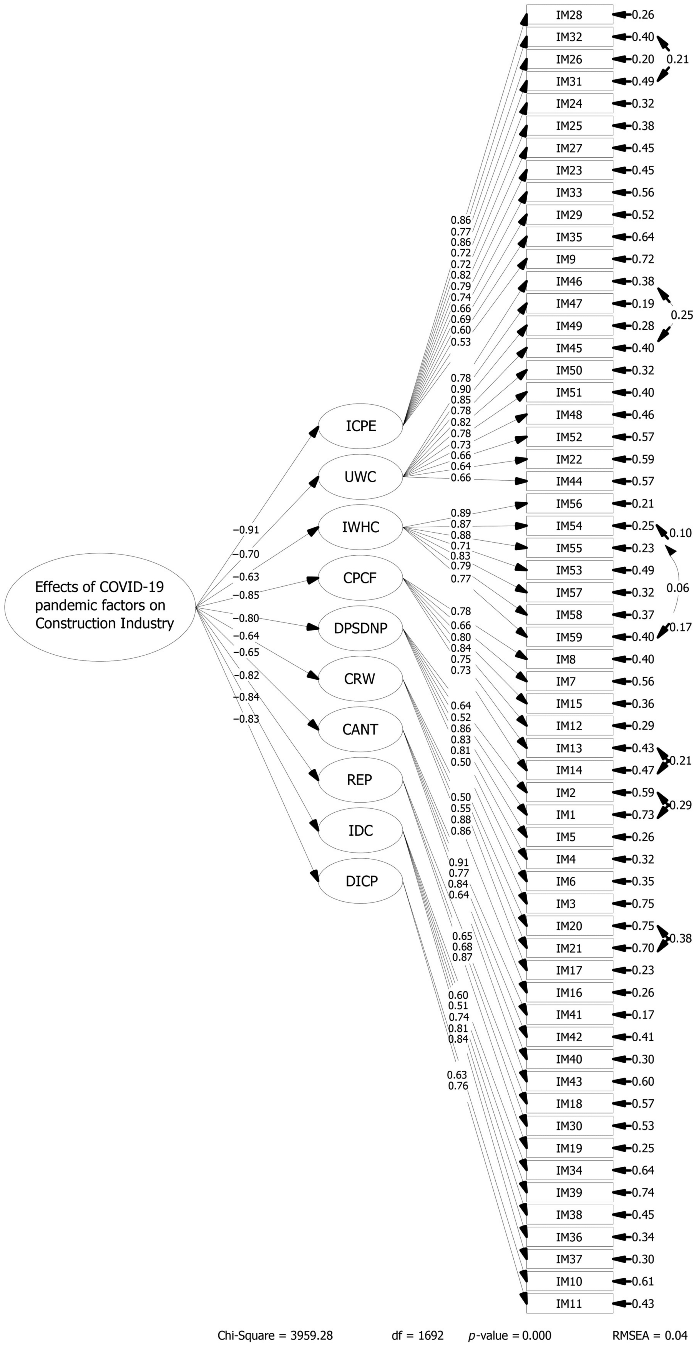

Figure 5.
Structural equation model of factors affecting construction industry during COVID-19

materials in the local market. When these three critical impacts were analysed, two key phrases were noted: increased project costs and challenges with supply chain. Construction activities have been impacted by the pandemic, particularly causing a disruption of global supply chains (Skyline Construction, 2020b) due to shortages of raw materials and other inputs, contractors, subcontractors and workers (AGC, 2020; Skyline Construction, 2020a). According to PwC's (2020) COVID-19 pulse survey results, most CFOs (81%) considered cost reduction and planned to cancel investments. As a reflection of this, numerous facilities have been shuttered for lengthy periods; thus, builders have experienced delays and cost increments for imported raw materials (e.g. steel, coils and tiles) (Consigli, 2020). Alsharef *et al.* (2021) and Assaad and El-Adaway (2021a) found that supply chain disruption has increased the cost of construction materials. Therefore, an overall business cost increment is inevitable due to the increase in cement, concrete-product and lumber costs. This argument is supported by Majumder and Biswas (2021). Moreover, an interconnectedness relationship exists between material supply-chain disruption and cost escalations. This finding agrees with the results of most construction industry studies (Agyekum *et al.*, 2022; Jeon *et al.*, 2022; Alsharef *et al.*, 2021; Assaad and El-adaway 2021b; Bousquin, 2021; Hou and Chen, 2021). Although some researchers have identified the causes, there are no studies regarding the factors affecting the construction industry. When the context and structure of the three most significant impacts of COVID-19 are analysed, their impacts are related to shortages of raw construction materials and the correspondingly increasing cost of construction production.

Table 4.
Summary statistics of model fitness indices

GOF	Suggested values	Observed values	Evaluation
χ^2/df	$0 \le \chi^2/\mathrm{df} \le 3$	2.34	Excellent
GFI	$0.95 \le \mathrm{GFI} \le 1.00$	0.97	Excellent
AGFI	$0.95 \le \mathrm{GFI} \le 1.00$	0.95	Excellent
RMSEA	$0 \le \mathrm{GFI} \le 0.05$	0.04	Excellent
CFI	$0.95 \le \mathrm{CFI} \le 1.00$	0.97	Excellent
NFI	$0.95 \le \mathrm{NFI} \le 1.00$	0.96	Excellent

Table 5.
Standardised coefficient estimates of the final model

Hypothetical paths and expected influences	Path coefficient*	*t*-value (1-tail)	R^2	Interpretation
H1: ICPE → CI	−0.91*	+8.33	0.83	Supported
H2: UWC → CI	−0.70*	+8.61	0.48	Supported
H3: IWHC → CI	−0.63*	+8.52	0.39	Supported
H4: CPCF → CI	−0.85*	+10.08	0.73	Supported
H5: DPSDNP → CI	−0.80*	+7.52	0.63	Supported
H6: CRW → CI	−0.64*	+9.30	0.41	Supported
H7: CANT → CI	−0.65*	+9.58	0.43	Supported
H8: REP → CI	−0.82*	+9.23	0.67	Supported
H9: IDC → CI	−0.84*	+8.84	0.70	Supported
H10: DICP → CI	−0.83*	+8.42	0.69	Supported

Note(s): *All standardised path coefficient estimates are expected to be significant at $p < 0.01$
ICPE: increased costs and price escalations due to limited raw materials and supply chain disruption UWC: unsafe working conditions regarding virus spread in workplace IWHC: increased workload, work-home conflict due to transition working from home CPCF: challenges with payment and cash flows DPSDNP: deceleration of ongoing projects or suspension and delay in the starting day for new projects CRW: challenges due to reduced workforce CANT: challenges in adapting to new technologies REP: reduction in efficiency and productivity IDC: increase in disputes and claims DICP: delays in inspections and construction permits CI: construction industry

5.2 Effect of profession differences on the perception of possible impacts of COVID-19

The literature review clearly shows that no studies have been conducted focussing on the differences in the stakeholder perception of the pandemic effects. Several stakeholders are present in the construction industry, playing different and crucial roles during the construction process. As each stakeholder conducts a particular aspect of the construction, they are exposed to different effects of the pandemic. Therefore, expecting the same reaction or perception for all stakeholders is not appropriate.

Seventeen items significantly affect the perceptions according to the profession within the construction industry (Table 2). Architects found impacts related to working from home, such as increased workload, reduced leisure time, work-home conflicts and lack of digital infrastructure, more influential than civil engineers and contractors.

Civil engineers followed by contractors were mostly affected by impacts which are focused on reducing the workforce due to the pandemic. In contrast, impacts pertaining to financial and contractual issues mostly affected the contractors, followed by civil engineers. The reason is that the contractors pay more concern to increased costs, disputes, claims and cash flow challenges. Conversely, architects might perform their work from home so that they were not affected as much as civil engineers and contractors.

5.3 COVID-19 related factors and their effects on the construction industry

Here, a framework for exploring and assessing the responses to COVID-19 in the construction industry was developed. Ten latent factors most affecting the construction industry were determined using EFA and CFA. The effects of the factors identified by SEM are discussed in the following sections.

5.3.1 Increased costs and price escalations due to shortage of raw materials and supply chain disruption (ICPE). The factor with the highest rank was ICPE, presenting an average IRI of 76.49%. This result shows that price escalations and cost increments play an essential role (Table 3). "Material price increments (IM9)" and "Fear of not being able to complete the construction (IM24)" impacts with IRIs of 90.11% and 82.64%, respectively, were ranked first and second in ICPE. The two primary corporate price escalations and cost increments are related to raw materials, supply chains and international shipping.

According to the ILO Sectoral Brief, 2021, with shortages of raw materials and other inputs, contractors and subcontractors, and labour, the pandemic's disruption of global supply chains has significantly affected construction work. In addition, PwC (2021a) stated that COVID-19 has had significant economic ramifications, and several vendors and subcontractors of engineering and construction firms may not be able to survive. Therefore, the pandemic imposed closures and shutdowns and reduced the capacity of manufacturing and processing facilities, which are upstream in the supply chain, increasing the cost of construction materials (Skyline Construction, 2020c). Moreover, the cost increment of raw construction materials (e.g. lumber, steel, cement, coils, concrete products and tiles) increased the overall business costs. Various cases have shown sudden revenue and financial shocks throughout the points in the supply chain (Alsharef *et al.*, 2021). An emerging obstacle is whether a project participant in charge of material and equipment has mitigated its supply chain damage. Therefore, suppliers are encouraged to seek alternative sources, materials and equipment rapidly to minimise delays (Daniels and Shreve, 2020).

China is the largest single supplier of imports to Turkey related to construction products and equipment. In particular, China accounted for almost 30% of total Turkish construction product imports. Moreover, numerous construction firms worldwide depend on China (up to 80% of the required materials) (Mew, 2020). Not only China but also other overseas suppliers are prone to delays (PwC, 2021a). Thus, construction-product supply chains in Turkey have been substantially affected and increasing the potential for cost increases. Furthermore, several construction companies have faced challenges with their material supply chains

(Skyline Construction, 2020b). The reason is that various international suppliers and logistics companies are closing operations to contain the outbreak (Mew, 2020).

These results are consistent with those of previous studies (ILO Sectoral Brief, 2021; PwC, 2021a; Alsharef *et al.*, 2021; Daniels and Shreve, 2020). Diversifying previous studies into the current research has shown that a shortage of raw materials combined with the supply chain disruptions strongly affected the construction industry. From this perspective, there is a knock-on effect among these variables.

Apart from the previous studies, this study revealed that the most influential COVID-19 factor to the construction industry was the "Increased costs and price escalations due to shortage of raw materials and supply chain disruption" with a path coefficient of −0.91.

5.3.2 Unsafe working conditions regarding virus spread in workplace (UWC). The factor UWC was ranked seventh with an IRI of 70.99%. This factor is associated with ten impacts, including "Lack of effective measures to prevent the virus spread (IM47)", with an average IRI of 72.94%. When this factor is analysed, several variables directly related to the spread of COVID-19 on construction sites and their consequences were determined.

Keeping workforce safe is another challenge during the pandemic (PwC, 2021a; OSHA, 2020a). The Occupational Safety and Health Administration classified job tasks with four risk exposure levels ranging from low-to very high-risk levels (OSHA, 2020a). Those who have high contact with suspected/infected people or people from contaminated zones have a higher risk of becoming infected. Thus, employees at construction sites, contractors, subcontractors, healthcare staff and those delivering services to COVID-19 patients are under the high-risk zone (Majumder and Biswas, 2021). Moreover, construction labourers come from different areas and work collaboratively, requiring face-to-face contact in shared workspaces and facilities; therefore, the virus spread is substantially high and inevitable (Simpeh and Amoah, 2021).

Several precautions from health authorities regarding the emergence of COVID-19 have been established. Common precautions include regular and thorough washing of hands with soap and water or using an alcohol-based hand rub or sanitiser to avoid the spread of the COVID-19 (WHO, 2020). Moreover, these precautions are under the responsibility of the employers. However, various safety measures are challenging to implement or are not fully enforced in construction sites. Furthermore, construction workers face a scarcity of personal protective equipment and lack efficient methods to prevent virus spread (Alsharef *et al.*, 2021).

This study showed parallelism with previous studies. The nature of construction works and insufficient precautions to spread the virus can be mentioned as one of the major causes of UWC. Here, "Unsafe working conditions regarding virus spread in workplace negatively affected the construction industry" had a −0.70-path coefficient, which differed from previous studies.

5.3.3 Increased workload, work-home conflict due to transition from workplace to home (IWHC). IWHC was ranked fourth, with an average IRI of 73.63%. Impact "Obstacles to focussing on work due to working from home (IM53)" was the most ranked impact of COVID-19 under this factor, with an IRI of 75.34%.

Numerous non-site professionals could opt to work from home in response to the pandemic, which enhanced safety but brought additional challenges. One such challenge is the increased workload suffered by many employees. The negative effect of work overload was reported in previous studies. In particular, these impacts may cause occupational stress, burnout and turnover intention that adversely affect organisations and the well-being of workers (Maslach and Leither, 2008; Sun *et al.*, 2020; Gumusburun Ayalp, 2021; Narayanamurthy and Totorella, 2021; Pirzadeh and Lingard, 2021).

The participants also highlighted that the lack of digital infrastructure to work from home (Internet outages, poor Internet quality) affects the transition to work from home. Therefore, obtaining essential software packages and other resources poses considerable challenges, resulting in severe inefficiencies. The COVID-19 pandemic gave a new perspective on remote working, and some companies have announced that they will continue to work remotely after the pandemic is over due to its benefits such as cost reduction and flexible working hours. Thus, municipalities will need to provide more digital and technical infrastructure services to citizens who work from home (PwC, 2021a). Furthermore, enhanced digitalisation and investments in digitisation are among the construction industry's current and future goals (McKinsey and Company, 2020). In numerous cases, companies must invest in improving their ability and capacity to work efficiently from home.

Apart from technology-related obstacles, distractions at home increased the challenge to work effectively. Employees working from home more than 2–3 days a week reported experiencing more negative health impacts (Raišienė *et al.*, 2020) than those who teleworked 1 or 2 days per week (Delanoeije and Verbruggen, 2020). Additional responsibilities at home, such as childcare (Alsharef *et al.*, 2021), make it difficult to work at home, causing work-home conflict (Hallin, 2020; Kniffin *et al.*, 2021). The transition to working from home induces work overload and work-home conflict arises. A contribution of this study is that the "Increased workload, work-home conflict due to transition from workplace to home" factor significantly affects the construction industry with a path coefficient of −0.63.

5.3.4 Challenges with payment and cash flows (CPCF). The CPCF factor ranked fifth among the factors, with an IRI of 73.44%. Within this factor, impact "Delays in payments and claims due to prolongation of project delivery time (IM8)" was the most significant, with an IRI of 78.32%.

Cash flow and payment concerns were due to increasing material prices and owners' difficulties in paying the contractors promptly. Therefore, many engineering and construction firms are experiencing financial difficulties, which will have a severe impact on their cash flow (PwC, 2021a). During the COVID-19 pandemic, several contractors incurred additional costs from liquidated damages. Project delays resulted in additional liabilities, affecting profit margins and project performance adversely. According to ASCE (2020), almost half of the organisations reported cash flow challenges. Alsharef *et al.* (2021) stated that delayed construction operations could increase payment delays, resulting in cash flow problems. Moreover, some contractors may delay payments to their workforce, subcontractors and suppliers (Skyline Construction, 2020a).

Another issue regarding CPCF is the contractors' and subcontractors' exposure to serious cash flow issues, which induced furloughs and layoffs due to their inability to pay their employees (Alsharef *et al.*, 2021).

The principal reason for CPCF is the disruption of material supply chains and material price escalations. Thus, CPCF causes suspension or delaying of projects, furloughs, layoffs and contractual dispute challenges. The results of previous meta-analyses support the obtained findings with an exception. In this study, the effect of the "Challenges with payment and cash flows" emerged as the second most important COVID-19 related influential factor affecting the construction industry with a −0.85 path coefficient.

5.3.5 Deceleration of ongoing projects or suspension and delay in the starting day for new projects (DPSDNP). DPSDNP was ranked second among factors, with an average IRI of 75.38%. In particular, "Financial uncertainties resulted in construction project investments cancellation and suspension (IM4)" emerged as the most important impact under this factor, with an overall IRI of 81.79%.

The direct effects of the pandemic varied from a shortage of materials and workforce to the suspension and, in some cases, cancellation of parties or entire projects (Holland and Knight, 2020). Although the construction industry has persisted, and several critical construction projects have continued working, COVID-19 has slowed down construction processes and caused disruption and delay due to the inability to obtain labour or material

(Alsharef *et al.*, 2021; Strickland, 2020). However, some projects have halted completely to resume work later (Bailey *et al.*, 2020).

According to the ASCE (2020) report, two-thirds of the organisations have faced contract cancellation or delays during the pandemic. Furthermore, one out of every seven organisations is experiencing potential contract penalties due to project delays. Therefore, a major difficulty encountered by construction projects is delays and suspensions of existing projects and slowed construction work owing to supply chain bottlenecks of equipment and supplies (Morris, 2020; PwC, 2020).

Another related impact is that new construction projects were particularly impacted as a majority of the projects in the frontend loading (FEL) phase (i.e. pre-project planning) were held. Moreover, several projects in the bidding stage were cancelled. Similar results were obtained in studies conducted by Alsharef *et al.* (2021).

Finally, the results of previous meta-analyses support the current quantitative research findings with one more exception. In this study, the effect of "Deceleration of ongoing projects or suspension and delay in the starting day for new projects" emerged as another significant COVID-19 related influential factor affecting the construction industry with a −0.80 path coefficient.

5.3.6 Challenges with reduced workforce (CRW). The factor CRW was ranked ninth based on the results of the IRI analysis (69.41%). In particular, impact "Fear of layoff (IM21)" was the most significant, with an average IRI of 74.06%.

Due to the limitations of equipment and materials and project cancellations, almost 40% of construction companies laid off workers during the pandemic (ENR, 2020). Moreover, the workforce limitations are expected to worsen at the oncoming waves of the pandemic due to infection and preventative quarantines (Franzese, 2020). As more construction workers become infected, quarantined labour periods would be more severe; thus, in an industry facing labour shortages, construction projects will be significantly affected (Brown, 2020). Furthermore, several project owners, developers and contractors have reduced their staff and site supervision workers to avoid and decrease redundant prolonged or additional costs due to construction project suspensions and slowdowns (Franzese, 2020).

Another labour obstacle for construction firms in the early wave of the pandemic was the lack of employees' rights, such as paid time off and sick leave. The CRW is also related to migrant workers' experience of tremendous uncertainty and financial difficulties. Most migrant workers were ceased and compelled to return to their countries where poverty and unemployment are severe (ILO, 2020 a, b). Those workers who remain in destination countries may face human rights violations and exploitation (ILO, 2020c).

In contrast to previous studies, the effect of "Challenges with reduced workforce" was negatively high on the construction industry, with a path coefficient of −0.64.

5.3.7 Challenges with adapting new technologies (CANT). Among the identified factors, CANT was ranked last, with an average IRI of 67.47%. The impacts "Accelerating the use of integrated project delivery systems such as BIM (IM43)", and "Adapting to new technologies challenges (IM41)" had IRIs of 68.85% and 68.75%, respectively, ranking first and second. CANT is an original factor of this study regarding the effect of COVID-19 on the construction industry, which negatively affects the sector with a path coefficient of − 0.65.

The use of integrated project delivery systems is an era for construction industry. Although the acceleration of the transition to these systems was perceived as a problem at the beginning of the pandemic, it is an important step to increase the efficiency of the construction sector. As a result, designers and engineers have started to decide on the basis of digital collaboration technologies such as BIM. To replan projects and reoptimize schedules, leading engineers and contractors are embracing 4D and 5D simulation (Simmons and Simmons, 2020). From project conception to commissioning, integrated digital-twin solutions are being developed to be used throughout the project life. Contractors are also using digital channels to monitor their employees' well-being via applications, acquire materials for construction, more accurately manage precious resources and preserve cash flow (McKinsey and Company, 2020).

Due to the pandemic, most employees and employers started working from home to decrease the number of people within construction firms, preserve social/physical distancing and decrease the spread rate of the virus. Therefore, technology use significantly increased in areas such as correspondence, meetings and webinars, which were initially conducted face-to-face (Gumble, 2020). Although working from home allowed continuation of most construction activities, studies showed that working from home could cause people to suffer from work-family conflicts, job burnout and mental well-being decreases (Hallin, 2020; Kniffin *et al.*, 2021). Moreover, some construction firms have rapidly adjusted to online meetings to cooperate and share knowledge, while other firms have adopted virtual site visits to monitor processes on-site and manage quality control (Jones *et al.*, 2020). However, most organisations have faced technological challenges with severe problems due to limited access to compatible electronic devices (Alsharef *et al.*, 2021; Araya, 2021; Kamal, 2020; Graves and Karabayeva, 2020). In several cases, computer literacy and access to qualified Internet networks are obstacles for employees (AGC, 2020; Parada, 2020; Alsharef *et al.*, 2021). In contrast, contractors and subcontractors lacked the required infrastructure to provide online training programs (Alsharef *et al.*, 2021; Swanek, 2020). The last problem related to online training is the lack of employees' participation in training, ending in one-sided conversations for trainers (Assaad and El-Adaway, 2021a, Zheng *et al.*, 2021).

5.3.8 Reduction in efficiency and productivity (REP). REP was ranked sixth, with an average IRI of 73.31%. Impact "Increased workforce and productivity shortages due to social distance (IM18)" emerged as the most significant, with an IRI of 74.84%.

Prior to the crisis, the industry was suffering from a shortage of skilled workforce. Skilled labour shortages became even more acute with the potential of rolling physical-distance measures and limits on cross-border labour mobility (McKinsey and Company, 2020), and this affected the efficiency and productivity of construction projects adversely. Construction industry productivity rates have declined during COVID-19 (Alsharef *et al.*, 2021; Kazeem, 2020). The increased safety precautions to protect employees as the pandemic progressed have reduced efficiency and productivity (Agyekum *et al.*, 2022; Narayanamurthy and Totorella, 2021). The first concern was developing a safety-working environment at the expense of productivity. A limited number of workers complying with social distance suggestions were also ascribed to the drop-in productivity rates (Graves and Karabeyava, 2020). According to Alsharef *et al.* (2021), workers chose not to report to work for various reasons (e.g. quarantining regulations, caring for children due to school closures and fear of becoming infected at work and becoming carriers of the virus while around family) in several cases. This aspect directly impacted production and efficiency.

The results of previous meta-analyses support the current quantitative research findings with one more exception. In this study, the effect of the factor "reduction in efficiency and productivity" emerged as the fifth influential factor affecting the construction industry with a −0.82 path coefficient, which is relatively high.

5.3.9 Increase in disputes and claims (IDC). The IDC was the third most influential factor, with an IRI of 74.41%. The impact "Contracts do not allow recovering the increased performance cost (IM38)" was the pioneering impact in this group, with an IRI of 77.98%. In this regard, arguments arise on how COVID-19 has affected the construction projects within legal elucidation. Project owners are terminating their contractual rights (for convenience) or partially or fully suspending construction projects to mitigate the negative economic impacts (Franzese, 2020). The disputes and claims are due to suspension of construction activities, delays, additional costs and material shortages (Assaad and Abdul-Malak, 2020).

Three main contractual problems are considered: applicability of the force majeure clause (Bailey *et al.*, 2020), changing laws to resolve disputes (Daniels and Shreve, 2020) and liquidated damages clauses (Assaad and Abdul-Malak, 2020).

The first category concerning "force majeure" refers to unforeseeable circumstances under which the contractors cannot fulfil a contract, which are not under the control of the parties and are unpreventable and unresolvable; consequently, a party cannot fulfil some or all of their responsibilities. Therefore, the COVID-19 pandemic might be considered a major force occurrence. However, the force majeure qualifies time extension to a contractor for delays but not to cost return during a delay, apart from agreed-upon circumstances (Yadeta, 2020).

The second category is related to changes in the law. For example, legal provisions change in current construction contracts may provide the contractor with the right to a time extension and a return for ineluctable costs, contrary to force majeure clauses that request a time extension (Bailey *et al.*, 2020).

The final category is liquidated damages clauses, which are legal and contractual reasons for conflicts in the construction industry (Assaad and Abdul-Malak, 2020). Material and price escalations are crucial aspects of this clause (Krulick, 2020). Because of the expected contractual and legal difficulties under various verdicts in their project agreements, contractors and subcontractors began to reserve their rights for additional costs and time, raising initial claims (Franzese, 2020).

Previous meta-analyses studies support the current quantitative research findings with one more exception. In this study, the effect of "increase in disputes and claims" emerged as a third vital COVID-19 related influential factor affecting the construction industry with a −0.84 path coefficient.

5.3.10 Delays in inspections and construction permits (DICP). The DICP was ranked eighth according to the results of the IRI analysis (70.69%). The impact "Delays with building permits from various governmental agencies prolong project delivery time (IM11)" was the dominant one, with an IRI of 71.69%.

Delays in inspections and licences are also significant pandemic effects. Most contractors have been facing project delays during the pandemic due to obstacles in obtaining required licences and inspections due to government offices closing or drastically reducing their availability (Dodge Data and Analytics, 2020). The leading cause of these delays is the transition to working at home. Alsharef *et al.* (2021) stated that public enterprises do not have a functional and efficient system with adequate technological assistance, making it difficult for a swift transition to modify operational changes for the required permits. Another cause was the cancellation and delay of inspection-related meetings due to suspension of face-to-face meetings. Final inducement originated from asymptomatic employees and shelter-in-place limitations on craftspeople who conduct inspections and perform issue-permit issues (Loulakis and McLaughlin, 2020).

The previous studies support the results of the current study within the context of "delays in inspections and construction permits". Apart from these, the current research showed that DICP is a crucial COVID-19 related factor negatively affecting the construction industry, with a path coefficient of −0.83.

6. Conclusions

This study implemented a multistage methodological framework to determine the influential factors of COVID-19 on the construction industry. First, 59 impacts of the pandemic were identified using the realistic review method, which considered how the pandemic affected the working environments of construction professionals, particularly architects, civil engineers and contractors. Second, EFA allowed determining ten influential factors. Finally, the factors affecting the construction industry were modelled through the LISREL software package.

Here, the perception of the pandemic impacts differed for each stakeholder. Architects were affected by working from home; civil engineers were influenced by a reduced workforce, and contractors were affected by increased costs, cash flow obstacles, disputes and claims. Ten influential factors were determined. The factor "Increased costs and price escalations due to limited raw materials and supply chain disruption (ICPE)" was the leading factor negatively affecting the construction industry. Moreover, CPCF, REP, IDC and DICP were the other significant factors affecting the sector adversely.

This model would be valuable for engineering and construction firms and also policy makers to realise the impacts of the current pandemic by both industry and company scale. Furthermore, it is certain that when the pandemic ends, engineering and construction companies will encounter a new world. To be prepared for a new construction marketplace, construction companies should initiate the transformation considering the impacts of the pandemic. Within this concept, this study has crucial empirical and management implications which are outlined below.

6.1 Conceptual contributions

The proposed model proved the negative impacts of the pandemic on the construction industry. This study comprehensively quantified the factors related to the COVID-19 pandemic affecting the construction industry. Four contributions were obtained. First, several impacts on the construction industry were found. Second, the CPIs were determined. Third, the perceived differences among construction professionals were obtained. Fourth, using SEM a model was developed to evaluate the effect of the factors on the construction industry, which led to an understanding of the most influential factors.

The developed model considered two new and original factors (CWPDD and CANT) specific to architects, civil engineers and contractors, which may be generalised to the construction industry.

To the best of our knowledge, no study has investigated the influential factors of the pandemic and modelled its effects using quantitative methods. Furthermore, this study made several conceptual and empirical advances which are as follows:

(1) From a theoretical perspective, understanding the pandemic's current effects on the Turkish construction industry could provide the global construction industry with a range of ideas about what actions to put in place to assure the industry's gradual to complete recovery.

(2) This study's findings include a substantial prediction tool (SEM) for discussing the influence of pandemic factors on the construction sector for the first time. Consequently, this tool has the potential to mitigate the adverse effects of this outbreak. This contribution is empirical in nature because it focused on providing a theoretical linkage between 10 pandemic factors affecting the construction industry which have not previously been tested.

6.2 Policy and managerial implications

This research also has policy and managerial implications for establishing more effective pandemic responses for the present COVID-19 pandemic, as well as future pandemics. The following policy and managerial implications can be used by engineering and construction companies and policy makers to understand the impact of the pandemic, to make strategies minimising the effects of the current impacts and get prepared for a new world after the pandemic.

Accordingly, "Increased costs and price escalations due to shortage of raw materials and supply chain disruption (ICPE)" and "Challenges in payment and cash flows (CPCF)" are the most influential COVID-19 factors on the construction industry, and thus, are worthy of attention. The following measures can be taken to mitigate the adverse effects of these factors. Regarding ICPE, identifying the supply chain vulnerabilities of the construction companies and choosing how to respond to them may be a beginning. Construction companies should contact their suppliers, acquire data and develop a dashboard that they keep on to update and develop over time. Companies should assess the legal and financial ramifications, as well as their effects on margins, cash flow, loan repayments and terms, based on what the dashboard displays. Securing crucial material suppliers and long-lead materials, as well as identifying alternative sources, may also help mitigate the adverse effects.

For critical material suppliers whose long-term prospects are sound, construction companies may want to offer contractual flexibility and technical support, including help in tapping government funding as part of recovery and stimulus programmes all over the world.

Regarding CPCF, companies should reinforce their financial position. With this regard, they should perform a comprehensive project-by-project projection and seek short-term government financial assistance. Furthermore, management teams should undertake about contractual terms, the recoverability of receivables in the case of site shutdown and the inevitable inefficiencies created by remote working and on-site distancing restrictions. In the medium term, many organisations will need to raise new equity. Developing a financial strategy will help construction companies be included among the strong group.

“Increase in disputes and claims (IDC)” is another influential pandemic factor for construction industry. To minimise the disputes and claims, impacts resulting from the COVID-19 outbreak should be examined carefully under the terms of any force majeure clause to see if they are covered as an excusable delay. Impacts from COVID-19 need to be carefully scrutinised to determine which legal remedies can be found. It should be determined whether the effects can be considered as force majeure according to the terms of the contract. The potential viability of common law remedies should be analysed (i.e. contractual non-enforceability/performance barrier).

Currently, we have learnt that COVID-19 has delayed and disrupted construction projects because supply chains have been affected substantially. Various construction works have been halted to continue later. The broad economic downturns and uncertainty created by the pandemic made owners, investors and companies less willing to engage in construction projects and operations. Consequently, various projects with an adverse impact on the construction industry have been temporarily suspended or cancelled. Thus, procuring alternatives for unpredictable price increments, working with local suppliers, locking in suppliers’ bids for prolonged periods (such as 30 and 90 days) and aiming to negotiate good agreements with suppliers may be a potential solution for “Deceleration of ongoing projects or suspension and delay in the starting day for new projects (DPSDNP)”.

To mitigate the adverse impacts of “Challenges in adapting to new technologies (CANT)”, digitalisation should be rolled out and accelerated in the construction industry. Organisations should enable well-proven remote use cases. For contractors, this may involve employing a digital approach to scale up remote collaboration during the construction stages or urging for minimal personnel at site offices. Engineering consultants should improve their BIM capability and collaboration tools. Construction materials manufacturers may need to confirm that their BIM is up to date, that they have e-commerce market access, and that they have effective, digitally enabled remote sales. Engineering and construction companies should make more investment for digitalisation, and governments should provide more incentives for this purpose.

Engineering and construction companies should disseminate the use of digital tools such as 4D simulations, digital workflow management, real-time progress tracking and advanced schedule optimisation which were proven to increase productivity to minimise the effects of

"Challenges due to reduced workforce (CRW)" and "Reduction in efficiency and productivity (REP)".

"Unsafe working conditions regarding virus spread in the workplace (UWC)" is another influential pandemic factor. Engineering and construction companies should take additional precautions to help employees stay safe, such as mandating safe distances between workers, staggering shifts and banning visitors. Apps for mobile devices may assist engineers and construction organisations to maintain track of workers' locations on the construction site, in full compliance with privacy standards, allowing them to swiftly identify possible virus exposures.

Since the beginning of the pandemic, most of the workers in the construction sector, as in many other sectors, continue to work from home. Considering the technological and technical difficulties of working from home, policy makers and governments should make greater investments in telecom and smart city initiatives to increase the technological infrastructure. Cyber security efforts need to be increased for employees who can work remotely. Now more sensitive information is needed on the internet and home systems. It is helpful to communicate regularly with these home-based workers and offer skills development options.

To sum up, policymakers may give priority to using available resources to establish short-term interventions aimed at reducing COVID-19's adversity. Furthermore, authorities can create long-term measures to mitigate the effects of future pandemics. The findings assist top and mid-level managers in understanding the risks that specific types of construction companies face as they navigate through the COVID-19 pandemic, from the managerial perspective. The findings can also be used by top-level managers to establish high-level action plans to prevent critical impacts from reoccurring in construction organisations. In conclusion, the main contribution of this study is to provide a better knowledge of the exposure that can exist across various construction organisations during global crises.

6.3 Limitations and future research

Despite the great efforts made in this study that significantly contribute to the identification of factors affecting the construction industry during the pandemic, it has several limitations. These limitations will lead future studies. First, it was limited in terms of geographical location. The research instrument (questionnaire) was administered to architects, civil engineers and contractors in Turkey. Future studies should seek to further explore other developing countries to improve the generalisability of the study which will build upon this work with new contributions. Besides architects, civil engineers and contractors, different stakeholders (material suppliers, quantity surveyors, building audit firms and other engineering groups) may be incorporated into the studies.

The developed SEM provided a good fit. Nevertheless, further studies should consider the effect of stress, anxiety, burnout and mental well-being. Moreover, further studies may examine contractual and legal aspects (law change effects, changes for force majeure clauses and its possible impacts); project delivery systems and workplace consideration (strategic methods for acceleration of BIM, integrated project delivery systems, use of virtual reality and artificial intelligence); workforce issues (effects of layoffs within economic, social and psychological aspects, effect of pandemic on construction workers' mental and physical health) and material and supply chain implications.

This study followed a generic approach to determine the COVID-19 related factors that affect the Turkish construction industry. Thus, these factors might be sensitive to the specific conditions of the region.

Finally, construction professionals, contractors and other stakeholders are advised to consider the aspects discussed in this study to reach the new normality.

References

Abed, S.S. (2021), "A literature review exploring the role of technology in business survival during the Covid-19 lockdowns", *International Journal of Organizational Analysis*, Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/IJOA-11-2020-2501.

Adabre, M.A., Chan, A.P., Darko, A., Osei-Kyei, R., Abidoye, R. and Adjei-Kumi, T. (2020), "Critical barriers to sustainability attainment in affordable housing: International construction professionals' perspective", *Journal of Cleaner Production*, Vol. 253, 119995.

Agyekum, K., Kukah, A.S. and Amudjie, J. (2022), "The impact of COVID-19 on the construction industry in Ghana: the case of some selected firms", *Journal of Engineering, Design and Technology*, Vol. 20 No. 1, pp. 222-224.

Aladağ, H., Demirdöğen, G. and Işık, Z. (2021), "Investigation of dispute factors and effects on construction projects arising from COVID-19 pandemic as a force majeure event", *Journal of the Faculty of Engineering and Architecture of Gazi University*, Vol. 36 No. 3, pp. 1213-1228.

Allen-Coghlan, M. and McQuinn, K.M. (2021), "The potential impact of Covid-19 on the Irish housing sector", *International Journal of Housing Markets and Analysis*, Vol. 14 No. 4, pp. 1753-8270.

Alsharef, A., Banerjee, S., Uddin, S.M.J., Albert, A. and Jaselskis, E. (2021), "Early impacts of the COVID-19 pandemic on the United States construction industry", *International Journal of Environmental Research and Public Health*, Vol. 18 No. 4, p. 1559.

Araya, F. (2021), "Modeling the spread of COVID-19 on construction workers: an agent-based approach", *Safety Science*, Vol. 133, 105022.

Asante, L.A. and Mills, R.O. (2020), "Exploring the socio-economic impact of COVID-19 pandemic in marketplaces in urban Ghana", *Africa Spectrum*, Vol. 55 No. 2, pp. 170-181.

ASCE (2020), "COVID-19 impact and implementation survey: executive summary", available at: http://images.message.asce.org/Web/AmericanSocietyOfCivilEngineersInc/%7Be9835dea929546d787700dede6d1e907%7D_COVID3asceV03.pdf?utm_campaign=Comm20200612ASCE%20News%20weekly&utm_medium=email&utm_source=Eloqua&elqTrackId=dfa0c97ba10344a881c2386d33f380c1&elq=9df2ece5ca6d4b2aa3c669924e232c56&elqaid=24424&elqat=1&elqCampaignId=13039 (accessed 5 January 2021).

Assaad, R. and Abdul-Malak, M.A. (2020), "Legal perspective on treatment of delay liquidated damages and penalty clauses by different jurisdictions: comparative analysis", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, Vol. 12 No. 2, 04520013.

Assaad, H.R. and El-Adaway, I. (2021a), "Guidelines for responding to COVID-19 pandemic: best practices, impacts, and future research directions", *Journal of Management in Engineering*, Vol. 37 No. 3, 06021001.

Assaad, R. and El-adaway, I.H. (2021b), "Impact of dynamic workforce and workplace variables on the productivity of the construction industry: new gross construction productivity indicator", *Journal of Management in Engineering*, Vol. 37 No. 1, 04020092, doi: 10.1061/(ASCE)ME.1943-5479.0000862.

Associated General Contractors of America (AGC) (2020), "Coronavirus has caused significant construction project delays and cancellations, yet demand for skilled labor is high, new survey finds", available at: https://www.agc.org/news/2020/09/02/coronavirus-has-caused-significant-construction-project-delays-and-cancellations-yet (accessed 15 January 2021).

Ayat, M. and Kang, C.W. (2021), "Effects of the COVID-19 pandemic on the construction sector: a systemized review", *Engineering, Construction and Architectural Management*, Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/ECAM-08-2021-0704.

B1M (2020), "How COVID-19 is impacting construction", available at: https://www.youtube.com/watch?v5JMsMBgNzaEc (accessed 15 April 2020).

Bailey, J., Bouchardie, N. and Madalena, I. (2020), "COVID-19: the current impact on construction and engineering projects", available at: https://www.whitecase.com/publications/alert/covid-19-current-impact-construction-engineering-projects (accessed 3 February 2021).

Baldwin, R. and Mauro, B. (2020), *Economics in the Time of COVID-19: A New eBook*, CEPR Press, a VoxEU.org., available at: https://voxeu.org/article/economics-time-covid-19-new-ebook (accessed 6 March 2021).

Berg, R.C. and Nanavati, J. (2016), "Realist review: current practice and future prospects", *Journal of Research Practice*, Vol. 12 No. 1, pp. 1-28.

Bon, R. (1992), "The future of international construction: secular patterns of growth and decline", *Habitat International*, Vol. 16 No. 3, pp. 119-128.

Bousquin, J. (2021), "5 charts that summarize a year of COVID-19 in construction", ConstructionDive, available at: https://www.constructiondive.com/news/5-charts-that-summarize-a-year-of-covid-19-in-construction/596675/ (accessed 8 January 2022).

Brown, L. (2020), "Construction industry bracing for potential impact of COVID-19", available at: https://www.globest.com/2020/03/16/construction-industry-bracing-for-potential-impact-of-covid-19/?slreturn=20220429150247 (accessed 29 May 2020).

Brown, T.A. and Moore, M.T. (2012), "Confirmatory factor analysis", in Holye, R.H. (Ed.), *Handbook of Structural Equation Modelling*, The Guilford Press, pp. 361-379.

Budds, D. (2020), "How essential is construction during the coronavirus pandemic?", available at: https://archive.curbed.com/2020/3/30/21199753/coronavirus-covid-19-construction-industry (accessed 28 March 2021).

Carlson, C. (2020), "Working from home 'the new normal' for architects and designers", available at: https://www.dezeen.com/2020/04/01/architects-designers-working-from-home-coronavirus (accessed 24 May 2022).

Casady, C.B. and Baxter, D. (2020), "Pandemics, public-private partnerships (PPPs), and force majeure COVID-19 expectations and implications", *Construction Management and Economics*, Vol. 38 No. 12, pp. 1077-1085.

Chen, Q., Garcia de Soto, B. and Adey, B. (2020), "Transshipment approach to coordinate materials for a contractor's project portfolio", *International Journal of Construction Management*, pp. 1-12, doi: 10.1080/15623599.2020.1840011.

Chin, W.W. (1998), "The partial least squares approach to structural equation modelling", in Marcoulides, G.A. (Ed.), *Modern Methods for Business Research*, Lawrence Erlbaum Associates Publishers, New Jersey, NJ, pp. 295-336.

Chou, Y.M., Polansky, A.M. and Mason, R.L. (1998), "Transforming non-normal data to normality in statistical process control", *Journal of Quality Technology*, Vol. 30 No. 2, pp. 133-141.

Cohen, J. (1988), *Statistical Power Analysis for the Behavioural Sciences*, 2nd ed., Lawrence Erlbaum Associates Publishers, New Jersey.

Consigli (2020), "COVID-19 Impact: construction materials", available at: https://www.consigli.com/covid-19-impact-to-construction-materials-2/ (accessed 24 March 2020).

Cronbach, L.J. (1951), "Coefficient alpha and the internal structure of tests", *Psychometrika*, Vol. 16, pp. 297-334.

Daniels, W.M. and Shreve, L.R. (2020), "The coronavirus effect on construction projects", available at: https://www.jdsupra.com/legalnews/the-coronavirus-effect-on-construction-13000/ (accessed 28 March 2021).

Delanoeije, J. and Verbruggen, M. (2020), "Between-person and within person effects of telework: a quasi-field experiment", *European Journal of Work and Organizational Psychology*, Vol. 29 No. 6, pp. 795-808.

Deloitte United States (2020), "Impact of COVID-19 on capital projects, construction programs", available at: https://www2.deloitte.com/us/en/pages/financial-advisory/articles/impact-of-covid-19-on-capital-projects-and-construction-programs.html (accessed 20 May 2022).

Department for Business, Energy and Industrial Strategy (BEIS) (2020), "Guidance on responsible contractual behaviour in the performance and enforcement of contracts impacted by the COVID-19 emergency", available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/883737/_Covid19_and_Responsible_Contractual_Behaviour_web_final_7_May.pdf (accessed 22 May 2022).

Dodge Data and Analytics (2020), “Keeping business going in a time of crisis”, available at: https://www.construction.com/toolkit/reports/keeping-business-going-in-time-ofcrisis (accessed 29 March 2021).

El-Gohary, K.M. and Aziz, R.F. (2014), “Factors influencing construction labor productivity in Egypt”, *Journal of Management in Engineering*, Vol. 30 No. 1, pp. 1-9.

ENR (Engineering News-Record) (2020), “Nearly 40% of firms have laid off workers, new AGC survey says”, available at: https://www.enr.com/articles/49166-nearly-40-of-firms-have-laid-off-workers-new-agc-survey-says?oly_enc_id=6990E2455378F3Z (accessed 29 January 2021).

Flyvbjerg, B. (2020), “The law of regression to the tail: how to survive Covid-19, the climate crisis, and other disasters”, *Environmental Science and Policy*, Vol. 114, pp. 614-618.

Franzese, N.P. (2020), “Potential impacts of the coronavirus pandemic on construction projects”, available at: https://www.natlawreview.com/article/potential-impacts-coronavirus-pandemic-construction-projects (accessed 28 March 2021).

Gan, H. and Koh, W.D. (2021), “COVID-19 and return-to-work for the construction sector: lessons from Singapore”, *Safety and Health at Work*, Vol. 12 No. 3, pp. 277-281.

Ghandour, A. (2020), “The impact of COVID-19 on project delivery: a Perspective from the construction sector in the United Arab Emirates”, *Humanities and Social Sciences Reviews*, Vol. 8 No. 5, pp. 169-177.

Giang, D. and Pheng, L. (2011), “Role of construction in economic development: review of key concepts in the past 40 years”, *Habitat International*, Vol. 35 No. 1, pp. 118-125.

Graves, L.M. and Karabayeva, A. (2020), “Managing virtual workers-strategies for success”, *IEEE Engineering Management Review*, Vol. 48 No. 2, pp. 166-172.

Gürcanlı, G.E., Mahcicek, S.B., Serpel, E. and Attia, S. (2021), “Factors affecting productivity of technical personnel in Turkish construction industry: a field study”, *Arabian Journal for Science and Engineering*, Vol. 46, pp. 11339-11353.

Gumble, C. (2020), “Making the best of a bad situation”, available at: https://www.constructionmanagermagazine.com/wpcontent/uploads/2020/06/Construction_Manager_May_2020.pdf (accessed 22 March 2021).

Gumusburun Ayalp, G. (2021), “Critical predictors of burnout among civil engineers at construction sites: a structural equation modelling”, *Engineering, Construction and Architectural Management*, Vol. 28 No. 7, pp. 0969-9988.

Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C. (1992), *Multivariate Data Analysis*, 3rd ed., Macmillan, New York, NY.

Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C. (2008), *Multivariate Data Analysis*, Prentice Hall Publisher, Upper Saddle River, New Jersey.

Hair, J.F. Jr, Hult, G.T.M., Ringle, C.M. and Sarstedt, M. (2017), *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, Sage Publications, Thousand Oaks, CA.

Hallin, H. (2020), “Home-based telework during the Covid-19 pandemic”, Master thesis, Malardalen University.

Harinarain, N. (2020), “Despair during the COVID-19 lockdown for the South African construction industry”, *Journal of Construction*, Vol. 13 No. 1, pp. 52-63.

Hesamian, G. (2016), “One-way ANOVA based on interval information”, *International Journal of Systems Science*, Vol. 47 No. 11, pp. 2682-2690.

Holland and Knight (2020), “A look at COVID-19 impacts on the construction industry”, available at: https://www.hklaw.com/en/insights/publications/2020/05/a-look-at-covid19-impacts-on-the-construction-industry (accessed 19 May 2022).

Hou, D. and Chen, Z. (2021), “Research on the application of Fama-French 5-factor model in the steel industry during COVID-19”, *Journal of Physics: Conference Series*, Vol. 1865 No. 4, 042104.

Hulme, K., Sehgal, C., Lucier, J. and (ConstructionCAN) (2020), “Navigating COVID 19: preparing for the future of construction”, (Video Webinar), available at: https://www.youtube.com/watch?v5aBCRwa0GxJg (accessed 20 May 2022).

Husien, I.A., Borisovich, Z. and Naji, A.A. (2021), “COVID-19: key global impacts on the construction industry and proposed coping strategies”, *E3S Web of Conferences EDP Sciences*, Vol. 263, 05056.

Iacobucci, D. (2009), “Structural equations modeling: fit indices, sample size, and advanced topics”, *Journal of Consumer Psychology*, Vol. 20 No. 1, pp. 90-98.

ILO (2020a), “Protecting migrant workers during the COVID-19 pandemic: recommendations for policy makers and constituents”, available at: https://www.ilo.org/wcmsp5/groups/public/—ed_protect/—protrav/—migrant/documents/publication/wcms_743268.pdf (accessed 30 April 2020).

ILO (2020b), “ILO warns of COVID-19 migrant ‘crisis within a crisis’”, available at: https://apmigration.ilo.org/news/ilo-warns-of-covid-19-migrant-2018crisis-within-a-crisis2019-1 (accessed 24 June 2020).

ILO (2020c), “Ensuring fair recruitment during the COVID-19 pandemic”, available at: https://www.ilo.org/global/topics/labour-migration/publications/WCMS_748839/lang–en/index.htm (accessed 23 June 2020).

ILO Sectoral Brief (2021), “Impact of COVID-19 on construction sector”, available at: https://www.ilo.org/sector/Resources/publications/WCMS_767303/lang–en/index.htm (accessed 30 April 2021).

Jeon, J., Padhye, S., Bhattacharyya, A., Cai, H. and Hastak, M. (2022), “Impact of COVID-19 on the US construction industry as revealed in the Purdue index for construction”, *Journal of Management in Engineering*, Vol. 38 No. 1, 04021082.

Jones, W., Chow, V. and Gibb, A. (2020), *COVID-19 and Construction: Early Lessons for a New Normal?*, Loughborough University, Loughborough, available at: https://www.balfourbeatty.com/media/318555/covid19-and-construction-early-lessons-fora- new-normal.pdf (accessed 7 January 2021).

Kamal, M.M. (2020), “The triple-edged sword of COVID-19: understanding the use of digital technologies and the impact of productive, disruptive, and destructive nature of the pandemic”, *Information Systems Management*, Vol. 37 No. 4, pp. 310-317.

Kazeem, Y. (2020), “Across Africa, a reliance on the informal sector threatens effective coronavirus lockdowns”, available at: https://qz.com/africa/1831785/coronavirus-citizens-in-africas-informaleconomy-try-to-survive/ (accessed 26 June 2021).

King, S.S., Rahman, R.A., Fauzi, M.A. and Haron, A.T. (2022), “Critical analysis of pandemic impact on AEC organizations: the COVID-19 case”, *Journal of Engineering, Design and Technology*, Vol. 20 No. 1, pp. 358-383.

Kniffin, K.M., Narayanan, J., Anseel, F., Antonakis, J., Ashford, S., Bakker, A.B., Bamberger, P., Bapuji, H., Bhave, D.P. and Choi, V.K. (2021), “COVID-19 and the workplace: implications, issues, and insights for future research and action”, *American Psychologist*, Vol. 76 No. 1, pp. 63-77.

Koh, D. (2020), “Migrant workers and COVID-19”, *Occupational and Environmental Medicine*, Vol. 77 No. 9, pp. 634-636.

Krulick, B.N. (2020), “Coronavirus is here: what does that mean for your project and your business?”, available at: https://www.smithcurrie.com/publications/client-alerts/coronavirus-is-here-what-does-that-mean-for-your-project-and-your-business/ (accessed 29 February 2021).

Lee, Z.P., Rahman, R.A. and Doh, S.I. (2021), “Critical success factors for implementing design-build: analysing Malaysian public projects”, *Journal of Engineering, Design and Technology*, Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/JEDT-08-2020-0321.

Lemke, M.K., Apostolopoulos, Y. and Sonmez, S. (2020), “A novel COVID-19 based truck driver syndemic? Implications for public health, safety, and vital supply chains”, *American Journal of Industrial Medicine*, Vol. 63 No. 8, pp. 659-662.

Levelset (2020), “How construction contractors can survive coronavirus”, available at: https://www.youtube.com/watch?v5Dab6gHc0g-Y (accessed 22 May 2022).

Lingard, H., Zhang, P.R., Räisänen, C., Goh, M.Y., Bowen, P. and Bhandari, S. (2021), “Special issue: what have we learnt from the COVID-19 global pandemic: improving the construction industry's abilities to foresee, respond to and recover from future endemic catastrophes", *Construction Management and Economics*, Vol. 39 No. 2, pp. 192-197.

Lohmöller, J.B. (1989), "Predictive vs. Structural modelling: PLS vs. ML", in Lohmöller, J.B. (Ed.), *Latent Variable Path Modelling with Partial Least Squares*, Springer, Heidelberg.

Loulakis, M.C. and McLaughlin, L.P. (2020), "The law: construction industry impacts in the COVID-19 world", available at: https://news.asce.org/the-law-construction-industry-impacts-in-the-covid-19-world/ (accessed 29 January 2021).

Majumder, S. and Biswas, D. (2021), "COVID-19 impacts construction industry: now, then and future", in Santosh, K.C. and Joshi, A. (Eds), *COVID-19: Prediction, Decision-Making, and its Impacts*, Springer, pp. 115-125.

Maslach, C. and Leiter, M.P. (2008), "Early predictors of job burnout and engagement", *Journal of Applied Psychology*, Vol. 93 No. 3, pp. 498-512.

McClure, E.S., Vasudevan, P., Bailey, Z., Patel, S. and Robinson, W.R. (2020), "Racial capitalism within public health: how occupational settings drive COVID-19 disparities", *American Journal of Epidemiology*, Vol. 189 No. 11, pp. 1244-1253.

McKinsey and Company (2020), "How construction can emerge stronger after coronavirus", available at: https://www.mckinsey.com/business-functions/operations/our-insights/how-construction-can-emerge-stronger-after-coronavirus (accessed 20 May 2022).

Mew, R. (2020), "Possible impacts of COVID-19 on construction markets", available at: https://www.snclavalin.com/en/beyond-engineering/possible-impacts-covid-19-on-construction-markets (accessed 27 January 2020).

Molwus, J., Erdogan, B. and Ogunlana, S. (2013), "Sample size and model fit indices for structural equation modelling (SEM): the case of construction management research", *ICCREM 2013 Proceedding, International Conference on Construction and Real Estate Management*, Reston, VA, 2013, ASCE, pp. 338-347.

Morris, G.D.L. (2020), "6 critical COVID - 19 risks for the construction industry", available at: https://riskandinsurance.com/6-critical-covid-19-risks-for-the-construction-industry/ (accessed 13 February 2021).

Narayanamurthy, G. and Tortorella, G. (2021), "Impact of COVID-19 outbreak on employee performance–moderating role of Industry 4.0 base technologies", *International Journal of Production Economics*, Vol. 234, 108075.

Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., Agha, M. and Agha, R. (2020), "The socio-economic implications of the coronavirus pandemic (COVID-19): a review", *International Journal of Surgery*, Vol. 78, June, pp. 185-193.

Nunnally, J.C. and Bernstein, I.H. (2007), *Psychometric Theory*, McGraw-Hill, New York, NY.

Occupational Safety and Health Administration (OSHA) (2020a), "Worker exposure risk to COVID-19", available at: https://www.osha.gov/sites/default/files/publications/OSHA3993.pdf (accessed 21 June 2021).

Occupational Safety and Health Administration (OSHA) (2020b), "COVID-19 control and prevention -construction work", available at: https://www.osha.gov/coronavirus/control-prevention/construction#:~:text=Keep%20in%2Dperson%20meetings%20(including,Fill%20hand%20sanitizer%20dispensers%20regularly (accessed 22 May 2022).

Office of National Statistics (ONS) (2020), "Causes of death: coronavirus (COVID-19) related deaths by occupation, england and wales: deaths registered between 9 March and 25 May 2020", available at: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/causesofdeath/bulletins/coronaviruscovid19relateddeathsbyoccupationenglandandwales/deathsregisteredbetween9marchand25may2020 (accessed 10 February 2021).

Ogunnusi, M., Hamma-adama, M., Salman, H. and Kouider, T. (2020), "COVID-19 pandemic: the effects and prospects in the construction industry", *International Journal of Real Estate Studies*, Vol. S214 No. 2020, pp. 120-128.

Ogunnusi, M., Omotayo, T., Hamma-Adama, M., Awuzie, B.O. and Egbelakin, T. (2022), "Lessons learned from the impact of COVID-19 on the global construction industry", *Journal of Engineering, Design and Technology*, Vol. 20 No. 1, pp. 299-320.

Oke, A.E., Ogunsami, D.R. and Ogunlana, S.O. (2012), "Establishing a common ground for the use of structural equation modelling for construction related research studies", *Australasian Journal of Construction Economics and Building*, Vol. 12 No. 3, pp. 89-94.

Okorie, V.N. and Musonda, I. (2020), "An investigation on supervisor's ability and competency to conduct construction site health and safety induction training in Nigeria", *International Journal of Construction Management*, Vol. 20 No. 5, pp. 357-366.

Pallant, J. (2005), *SPSS Survival Manual*, Open University Press, Berkshire.

Parada, J. (2020), "COVID-19's impact on the engineering & construction sector", available at: https://www2.deloitte.com/global/en/pages/about-deloitte/articles/covid-19/understanding-the-sector-impact-of-covid-19–engineering—const.html (accessed 5 January 2022).

Pawson, R., Greenhalgh, T., Harvey, G. and Walshe, K. (2005), "Realist review—a new method of systematic review designed for complex policy interventions", *Journal of Health Services Research and Policy*, Vol. 10 No. 1, pp. 21-34.

Pirzadeh, P. and Lingard, H. (2021), "Working from home during the COVID-19 pandemic: health and well-being of project-based construction workers", *Journal of Construction Engineering and Management*, Vol. 147 No. 6, 04021048.

PwC United States (2020), "PwC's COVID-19 CFO pulse", available at: https://www.pwc.com/gx/en/issues/crisis-solutions/covid-19/global-cfo-pulse.html (accessed 20 May 2022).

PwC United States (2021a), "Engineering & Construction in a post-COVID world: weathering the storm", available at: https://www.pwc.com/gx/en/issues/crisis-solutions/covid-19/engineering-construction-post-covid-world.html (accessed 22 May 2022).

PwC United States (2021b), "Global crisis survey", available at: https://www.pwc.com/gx/en/issues/crisis-solutions/global-crisis-survey.html (accessed 30 May 2022).

Raišienė, A.G., Rapuano, V., Varkulevičiūtė, K. and Stachová, K. (2020), "Working from home—who is happy? A survey of Lithuania's employees during the COVID-19 quarantine period", *Sustainability*, Vol. 12 No. 13, 5332.

Rehman, M.S.U., Shafig, M.T. and Afzal, M. (2022), "Impact of COVID-19 on project performance in the UAE construction industry", *Journal of Engineering, Design and Technology*, Vol. 20 No. 1, pp. 245-266.

Ruddock, L. and Lopes, J. (2006), "The construction sector and economic development: the 'Bon curve'", *Construction Management and Economics*, Vol. 24 No. 7, pp. 717-723.

Schreiber, J.B., Nora, A., Stage, F.K., Barlow, E.A. and King, J. (2006), "Reporting structural equation modeling and confirmatory factor analysis results: a review", *The Journal of Educational Research*, Vol. 99 No. 6, pp. 323-338.

Sertyesilişik, B. (2017), "Global trends in the construction industry: challenges of employment", in Yenilmez, F. and Kılıç, E. (Eds), *Handbook of Research on Unemployment and Labour Market Sustainability in the Era of Globalisation*, IGI Global Publisher, pp. 255-274.

Sierra, F. (2022), "COVID-19: main challenges during construction stage", *Engineering, Construction and Architectural Management*, Vol. 29 No. 4, pp. 1817-1834.

Simmons and Simmons (2020), "COVID-19: impacts on construction projects in the Middle East", available at: https://www.simmons-simmons.com/en/publications/ck7yjeifa0r1m0951yvoqlc49/covid-19-impact-on-construction-projects-in-the-middle-east (accessed 21 May 2022).

Simpeh, F. and Amoah, C. (2021), "Assessment of measures instituted to curb the spread of COVID-19 on construction site", *International Journal of Construction Management*, Vol. 21 No. 10, pp. 1-9.

Skyline Construction (2020a), "How COVID-19 impacts construction subcontractors (video)", available at: https://www.youtube.com/watch?v=kv5kImdBw60 (accessed 24 May 2022).

Skyline Construction (2020b), “COVID-19 Impacts to construction supply chain (video)”, available at: https://www.youtube.com/watch?v=zBa0-_4TEgg (accessed 24 May 2022).

Skyline Construction (2020c), “How COVID-19 Impacts costs on construction projects (video)”, available at: https://www.youtube.com/watch?v=647zj0UILLs (accessed 24 May 2022).

Staplehurst, J. and Ragsdell, G. (2010), “Knowledge sharing in SMEs: a comparison of two case study organisations”, *Journal of Knowledge Management Practice*, Vol. 11 No. 1, pp. 1-16.

Stiles, S., Golightly, D. and Ryan, B. (2021), “Impact of COVID-19 on health and safety in the construction sector”, *Human Factors and Ergonomics in Manufacturing and Service Industries*, Vol. 31 No. 5, pp. 425-437.pp.

Strickland, J.T. (2020), “Addressing financial impacts of the COVID-19 crisis on construction companies”, available at: https://www.natlawreview.com/article/addressing-financial-impacts-covid-19-crisis-construction-companies (accessed 13 March 2021).

Sun, M., Zhu, F. and Sun, X. (2020), “Influencing factors of construction professionals’ burnout in China: a sequential mixed-method approach”, *Engineering, Construction and Architectural Management*, Vol. 27 No. 10, pp. 3215-3233.

Swanek, T. (2020), “New study finds commercial construction facing shortages due to COVID”, US Chamber of Commerce, available at: https://www.uschamber.com/economy/new-study-finds-commercial-construction-facing-shortages-due-covid#:~:text=Thaddeus%20Swanek&text=The%20Q4%202020%20U.S.%20Chamber,up%20from%2057%20in%20Q3 (accessed 8 January 2021).

Tavakol, M. and Dennick, R. (2011), “Making sense of Cronbach’s alpha”, *International Journal of Medical Education*, Vol. 2, pp. 53-55.

Tekce, M. (2020), “Impacts of COVID-19 pandemic on Turkish construction sector”, Korea Institute for International Economic Policy, Analysis of the Turkish Services Industry and Recommendations for Korea-Turkey Cooperation, Part 2, available at: https://www.kiep.go.kr/gallery.es?mid=a20303000000&bid=0001&list_no=2400&act=view (accessed 23 January 2022).

Turkish Contractor Association (2016), “İnşaat Sektörü Analizi, 2016 Zor Bir Yıl Olacak (in Turkish)”, available at: https://www.tmb.org.tr/tr//pubs/60645e1862b4983868938aef/tmb-analiz-bulteni?y=2016 (accessed 8 February 2021).

TURKSTAT - Türkiye İstatistik Kurumu (2021), available at: https://www.tuik.gov.tr/ (accessed June 2021).

Viewpoint (2020), “COVID-19 Survey: how the construction industry is adapting”, available at: https://info.viewpoint.com/rs/623-NDA-487/images/COVID_Survey_Results.pdf (accessed 29 February 2021).

Wang, W., Gao, S., Mi, L., Xing, J., Shang, K., Qiao, Y., Fu, Y., Ni, G. and Xu, N. (2021), “Exploring the adoption of BIM amidst the COVID-19 crisis in China”, *Building Research and Information*, Vol. 49 No. 8, pp. 930-947.

Wildenauer, A.A. (2021), “An exploration of COVID-19 and Its consideration as a black swan for the construction Industry in Switzerland”, *International Journal of Digital Innovation in the Built Environment*, Vol. 10 No. 1, pp. 62-82.

World Health Organization (WHO) (2020), “Q&A on coronaviruses (COVID- 19)”, available at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/q-acoronaviruses (accessed 15 February 2021).

Yadeta, A.E. (2020), “Analysis of the global impact of the pandemic (COVID-19) on construction industry: possible scenarios”, *Current Trends in Civil and Structural Engineering*, Vol. 6 No. 4, pp. 4-11.

Zhao, Z.Y. and Chen, Y.L. (2018), “Critical factors affecting the development of renewable energy power generation: evidence from China”, *Journal of Cleaner Production*, Vol. 184, pp. 466-480.

Zheng, L., Chen, K. and Ma, L. (2021), “Knowledge, attitudes, and practices toward COVID-19 among construction industry practitioners in China”, *Frontiers in Public Health*, Vol. 8, pp. 1-9.

Appendix

Table A1. Tukey HSD (honestly significant difference) test: significantly different among groups

Dependent variable	(I) Profession	(J) Profession	Mean difference (I−J)	Std. error	Sig.
IM1	Architect	Civil engineer	−0.680*	0.140	0.000
		Contractor	−0.591*	0.165	0.001
	Civil engineer	Architect	0.680*	0.140	0.000
		Contractor	0.089	0.175	0.866
	Contractor	Architect	0.591*	0.165	0.001
		Civil engineer	−0.089	0.175	0.866
IM2	Architect	Civil engineer	−0.565*	0.137	0.000
		Contractor	−0.506*	0.162	0.006
	Civil engineer	Architect	0.565*	0.137	0.000
		Contractor	0.059	0.171	0.936
	Contractor	Architect	0.506*	0.162	0.006
		Civil engineer	−0.059	0.171	0.936
IM3	Architect	Civil engineer	−0.063	0.146	0.904
		Contractor	−0.610*	0.173	0.001
	Civil engineer	Architect	0.063	0.146	0.904
		Contractor	−0.548*	0.183	0.008
	Contractor	Architect	0.610*	0.173	0.001
		Civil engineer	0.548*	0.183	0.008
IM4	Architect	Civil engineer	0.047	0.141	0.939
		Contractor	−0.055	0.166	0.942
	Civil engineer	Architect	−0.047	0.141	0.939
		Contractor	−0.102	0.176	0.830
	Contractor	Architect	0.055	0.166	0.942
		Civil engineer	0.102	0.176	0.830
IM5	Architect	Civil engineer	−0.099	0.142	0.764
		Contractor	−0.185	0.168	0.511
	Civil engineer	Architect	0.099	0.142	0.764
		Contractor	−0.086	0.177	0.878
	Contractor	Architect	0.185	0.168	0.511
		Civil engineer	0.086	0.177	0.878
IM6	Architect	Civil engineer	−0.369*	0.130	0.014
		Contractor	−0.453*	0.154	0.010
	Civil engineer	Architect	0.369*	0.130	0.014
		Contractor	−0.084	0.163	0.864
	Contractor	Architect	0.453*	0.154	0.010
		Civil engineer	0.084	0.163	0.864
IM7	Architect	Civil engineer	−0.315	0.153	0.100
		Contractor	−0.554*	0.180	0.007
	Civil engineer	Architect	0.315	0.153	0.100
		Contractor	−0.239	0.191	0.422
	Contractor	Architect	0.554*	0.180	0.007
		Civil engineer	0.239	0.191	0.422
IM8	Architect	Civil engineer	−0.312	0.137	0.062
		Contractor	−0.258	0.162	0.251
	Civil engineer	Architect	0.312	0.137	0.062
		Contractor	0.054	0.171	0.947
	Contractor	Architect	0.258	0.162	0.251
		Civil engineer	−0.054	0.171	0.947

(*continued*)

Dependent variable	(I) Profession	(J) Profession	Mean difference (I−J)	Std. error	Sig.
IM9	Architect	Civil engineer	−0.180	0.106	0.211
		Contractor	−0.403*	0.126	0.004
	Civil engineer	Architect	0.180	0.106	0.211
		Contractor	−0.223	0.133	0.217
	Contractor	Architect	0.403*	0.126	0.004
		Civil engineer	0.223	0.133	0.217
IM10	Architect	Civil engineer	−0.055	0.141	0.918
		Contractor	−0.260	0.166	0.265
	Civil engineer	Architect	0.055	0.141	0.918
		Contractor	−0.204	0.176	0.477
	Contractor	Architect	0.260	0.166	0.265
		Civil engineer	0.204	0.176	0.477
IM11	Architect	Civil engineer	−0.170	0.148	0.487
		Contractor	−0.352	0.175	0.111
	Civil engineer	Architect	0.170	0.148	0.487
		Contractor	−0.182	0.185	0.586
	Contractor	Architect	0.352	0.175	0.111
		Civil engineer	0.182	0.185	0.586
IM12	Architect	Civil engineer	−0.109	0.131	0.682
		Contractor	−0.385*	0.155	0.036
	Civil engineer	Architect	0.109	0.131	0.682
		Contractor	−0.276	0.164	0.213
	Contractor	Architect	0.385*	0.155	0.036
		Civil engineer	0.276	0.164	0.213
IM13	Architect	Civil engineer	−0.583*	0.154	0.001
		Contractor	−0.120	0.182	0.788
	Civil engineer	Architect	0.583*	0.154	0.001
		Contractor	0.463*	0.193	0.045
	Contractor	Architect	0.120	0.182	0.788
		Civil engineer	−0.463*	0.193	0.045
IM14	Architect	Civil engineer	−0.541*	0.139	0.000
		Contractor	−0.300	0.164	0.161
	Civil engineer	Architect	0.541*	0.139	0.000
		Contractor	0.241	0.173	0.348
	Contractor	Architect	0.300	0.164	0.161
		Civil engineer	−0.241	0.173	0.348
IM15	Architect	Civil engineer	−0.236	0.130	0.169
		Contractor	−0.385*	0.154	0.035
	Civil engineer	Architect	0.236	0.130	0.169
		Contractor	−0.149	0.163	0.630
	Contractor	Architect	0.385*	0.154	0.035
		Civil engineer	0.149	0.163	0.630
IM16	Architect	Civil engineer	−0.241	0.148	0.236
		Contractor	0.220	0.175	0.421
	Civil engineer	Architect	0.241	0.148	0.236
		Contractor	0.462*	0.185	0.036
	Contractor	Architect	−0.220	0.175	0.421
		Civil engineer	−0.462*	0.185	0.036
IM17	Architect	Civil engineer	−0.366	0.160	0.059
		Contractor	0.382	0.189	0.109
	Civil engineer	Architect	0.366	0.160	0.059
		Contractor	0.748*	0.200	0.001
	Contractor	Architect	−0.382	0.189	0.109
		Civil engineer	−0.748*	0.200	0.001

Table A1. *(continued)*

Dependent variable	(I) Profession	(J) Profession	Mean difference (I−J)	Std. error	Sig.
IM18	Architect	Civil engineer	−0.123	0.140	0.654
		Contractor	−0.364	0.165	0.074
	Civil engineer	Architect	0.123	0.140	0.654
		Contractor	−0.241	0.175	0.355
	Contractor	Architect	0.364	0.165	0.074
		Civil engineer	0.241	0.175	0.355
IM19	Architect	Civil engineer	−0.407*	0.145	0.015
		Contractor	−0.339	0.171	0.118
	Civil engineer	Architect	0.407*	0.145	0.015
		Contractor	0.068	0.181	0.925
	Contractor	Architect	0.339	0.171	0.118
		Civil engineer	−0.068	0.181	0.925
IM20	Architect	Civil engineer	−0.763*	0.145	0.000
		Contractor	−0.083	0.171	0.878
	Civil engineer	Architect	0.763*	0.145	0.000
		Contractor	0.679*	0.181	0.001
	Contractor	Architect	0.083	0.171	0.878
		Civil engineer	−0.679*	0.181	0.001
IM21	Architect	Civil engineer	−0.538*	0.153	0.002
		Contractor	−0.096	0.181	0.856
	Civil engineer	Architect	0.538*	0.153	0.002
		Contractor	0.442	0.191	0.056
	Contractor	Architect	0.096	0.181	0.856
		Civil engineer	−0.442	0.191	0.056
IM22	Architect	Civil engineer	−0.129	0.148	0.660
		Contractor	0.129	0.175	0.742
	Civil engineer	Architect	0.129	0.148	0.660
		Contractor	0.258	0.185	0.347
	Contractor	Architect	−0.129	0.175	0.742
		Civil engineer	−0.258	0.185	0.347
IM23	Architect	Civil engineer	−0.261	0.144	0.167
		Contractor	−0.215	0.170	0.416
	Civil engineer	Architect	0.261	0.144	0.167
		Contractor	0.046	0.180	0.964
	Contractor	Architect	0.215	0.170	0.416
		Civil engineer	−0.046	0.180	0.964
IM24	Architect	Civil engineer	0.076	0.131	0.831
		Contractor	−0.135	0.155	0.661
	Civil engineer	Architect	−0.076	0.131	0.831
		Contractor	−0.211	0.164	0.405
	Contractor	Architect	0.135	0.155	0.661
		Civil engineer	0.211	0.164	0.405
IM25	Architect	Civil engineer	−0.049	0.133	0.929
		Contractor	−0.228	0.157	0.316
	Civil engineer	Architect	0.049	0.133	0.929
		Contractor	−0.179	0.166	0.527
	Contractor	Architect	0.228	0.157	0.316
		Civil engineer	0.179	0.166	0.527
IM26	Architect	Civil engineer	−0.157	0.142	0.511
		Contractor	−0.210	0.168	0.426
	Civil engineer	Architect	0.157	0.142	0.511
		Contractor	−0.052	0.178	0.953
	Contractor	Architect	0.210	0.168	0.426
		Civil engineer	0.052	0.178	0.953

(*continued*)

Table A1.

Dependent variable	(I) Profession	(J) Profession	Mean difference (I–J)	Std. error	Sig.
IM27	Architect	Civil engineer	−0.250	0.137	0.164
		Contractor	0.062	0.162	0.923
	Civil engineer	Architect	0.250	0.137	0.164
		Contractor	0.312	0.171	0.165
	Contractor	Architect	−0.062	0.162	0.923
		Civil engineer	−0.312	0.171	0.165
IM28	Architect	Civil engineer	−0.205	0.138	0.299
		Contractor	−0.155	0.163	0.611
	Civil engineer	Architect	0.205	0.138	0.299
		Contractor	0.051	0.172	0.954
	Contractor	Architect	0.155	0.163	0.611
		Civil engineer	−0.051	0.172	0.954
IM29	Architect	Civil engineer	−0.102	0.139	0.743
		Contractor	−0.184	0.164	0.505
	Civil engineer	Architect	0.102	0.139	0.743
		Contractor	−0.081	0.174	0.886
	Contractor	Architect	0.184	0.164	0.505
		Civil engineer	0.081	0.174	0.886
IM30	Architect	Civil engineer	0.127	0.148	0.666
		Contractor	−0.163	0.175	0.618
	Civil engineer	Architect	−0.127	0.148	0.666
		Contractor	−0.291	0.185	0.259
	Contractor	Architect	0.163	0.175	0.618
		Civil engineer	0.291	0.185	0.259
IM31	Architect	Civil engineer	−0.193	0.130	0.300
		Contractor	−0.183	0.153	0.460
	Civil engineer	Architect	0.193	0.130	0.300
		Contractor	0.010	0.162	0.998
	Contractor	Architect	0.183	0.153	0.460
		Civil engineer	−0.010	0.162	0.998
IM32	Architect	Civil engineer	−0.058	0.136	0.905
		Contractor	−0.024	0.161	0.988
	Civil engineer	Architect	0.058	0.136	0.905
		Contractor	0.034	0.170	0.978
	Contractor	Architect	0.024	0.161	0.988
		Civil engineer	−0.034	0.170	0.978
IM33	Architect	Civil engineer	0.063	0.136	0.890
		Contractor	−0.127	0.161	0.709
	Civil engineer	Architect	−0.063	0.136	0.890
		Contractor	−0.190	0.170	0.505
	Contractor	Architect	0.127	0.161	0.709
		Civil engineer	0.190	0.170	0.505
IM34	Architect	Civil engineer	−0.160	0.123	0.396
		Contractor	−0.045	0.145	0.948
	Civil engineer	Architect	0.160	0.123	0.396
		Contractor	0.115	0.154	0.735
	Contractor	Architect	0.045	0.145	0.948
		Civil engineer	−0.115	0.154	0.735
IM35	Architect	Civil engineer	−0.173	0.133	0.396
		Contractor	−0.045	0.157	0.956
	Civil engineer	Architect	0.173	0.133	0.396
		Contractor	0.128	0.166	0.721
	Contractor	Architect	0.045	0.157	0.956
		Civil engineer	−0.128	0.166	0.721

Table A1.

(*continued*)

Dependent variable	(I) Profession	(J) Profession	Mean difference (I−J)	Std. error	Sig.
IM36	Architect	Civil engineer	−0.220	0.135	0.235
		Contractor	−0.096	0.160	0.819
	Civil engineer	Architect	0.220	0.135	0.235
		Contractor	0.124	0.169	0.743
	Contractor	Architect	0.096	0.160	0.819
		Civil engineer	−0.124	0.169	0.743
IM37	Architect	Civil engineer	0.000	0.133	10.000
		Contractor	0.007	0.158	0.999
	Civil engineer	Architect	0.000	0.133	10.000
		Contractor	0.007	0.167	0.999
	Contractor	Architect	−0.007	0.158	0.999
		Civil engineer	−0.007	0.167	0.999
IM38	Architect	Civil engineer	−0.071	0.132	0.854
		Contractor	−0.194	0.156	0.427
	Civil engineer	Architect	0.071	0.132	0.854
		Contractor	−0.124	0.165	0.734
	Contractor	Architect	0.194	0.156	0.427
		Civil engineer	0.124	0.165	0.734
IM39	Architect	Civil engineer	0.018	0.141	0.991
		Contractor	−0.251	0.167	0.289
	Civil engineer	Architect	−0.018	0.141	0.991
		Contractor	−0.270	0.176	0.278
	Contractor	Architect	0.251	0.167	0.289
		Civil engineer	0.270	0.176	0.278
IM40	Architect	Civil engineer	−0.087	0.142	0.814
		Contractor	0.105	0.167	0.805
	Civil engineer	Architect	0.087	0.142	0.814
		Contractor	0.192	0.177	0.525
	Contractor	Architect	−0.105	0.167	0.805
		Civil engineer	−0.192	0.177	0.525
IM41	Architect	Civil engineer	−0.005	0.141	0.999
		Contractor	−0.153	0.167	0.629
	Civil engineer	Architect	0.005	0.141	0.999
		Contractor	−0.148	0.176	0.678
	Contractor	Architect	0.153	0.167	0.629
		Civil engineer	0.148	0.176	0.678
IM42	Architect	Civil engineer	−0.063	0.145	0.900
		Contractor	−0.220	0.171	0.404
	Civil engineer	Architect	0.063	0.145	0.900
		Contractor	−0.157	0.181	0.661
	Contractor	Architect	0.220	0.171	0.404
		Civil engineer	0.157	0.181	0.661
IM43	Architect	Civil engineer	0.074	0.142	0.860
		Contractor	−0.247	0.168	0.305
	Civil engineer	Architect	−0.074	0.142	0.860
		Contractor	−0.322	0.177	0.167
	Contractor	Architect	0.247	0.168	0.305
		Civil engineer	0.322	0.177	0.167
IM44	Architect	Civil engineer	0.184	0.127	0.319
		Contractor	−0.124	0.150	0.687
	Civil engineer	Architect	−0.184	0.127	0.319
		Contractor	−0.308	0.159	0.130
	Contractor	Architect	0.124	0.150	0.687
		Civil engineer	0.308	0.159	0.130

(*continued*)

Table A1.

Dependent variable	(I) Profession	(J) Profession	Mean difference (I−J)	Std. error	Sig.
IM45	Architect	Civil engineer	0.165	0.148	0.502
		Contractor	0.475*	0.174	0.019
	Civil engineer	Architect	−0.165	0.148	0.502
		Contractor	0.309	0.184	0.216
	Contractor	Architect	−0.475*	0.174	0.019
		Civil engineer	−0.309	0.184	0.216
IM46	Architect	Civil engineer	0.176	0.147	0.455
		Contractor	0.277	0.174	0.249
	Civil engineer	Architect	−0.176	0.147	0.455
		Contractor	0.101	0.183	0.846
	Contractor	Architect	−0.277	0.174	0.249
		Civil engineer	−0.101	0.183	0.846
IM47	Architect	Civil engineer	0.262	0.143	0.163
		Contractor	0.371	0.169	0.075
	Civil engineer	Architect	−0.262	0.143	0.163
		Contractor	0.109	0.179	0.815
	Contractor	Architect	−0.371	0.169	0.075
		Civil engineer	−0.109	0.179	0.815
IM48	Architect	Civil engineer	−0.225	0.147	0.279
		Contractor	0.168	0.174	0.596
	Civil engineer	Architect	0.225	0.147	0.279
		Contractor	0.393	0.183	0.083
	Contractor	Architect	−0.168	0.174	0.596
		Civil engineer	−0.393	0.183	0.083
IM49	Architect	Civil engineer	0.070	0.139	0.870
		Contractor	0.301	0.164	0.160
	Civil engineer	Architect	−0.070	0.139	0.870
		Contractor	0.232	0.173	0.377
	Contractor	Architect	−0.301	0.164	0.160
		Civil engineer	−0.232	0.173	0.377
IM50	Architect	Civil engineer	0.091	0.133	0.774
		Contractor	0.077	0.157	0.877
	Civil engineer	Architect	−0.091	0.133	0.774
		Contractor	−0.014	0.166	0.996
	Contractor	Architect	−0.077	0.157	0.877
		Civil engineer	0.014	0.166	0.996
IM51	Architect	Civil engineer	−0.170	0.135	0.422
		Contractor	−0.054	0.160	0.940
	Civil engineer	Architect	0.170	0.135	0.422
		Contractor	0.117	0.169	0.770
	Contractor	Architect	0.054	0.160	0.940
		Civil engineer	−0.117	0.169	0.770
IM52	Architect	Civil engineer	0.062	0.134	0.889
		Contractor	0.277	0.158	0.187
	Civil engineer	Architect	−0.062	0.134	0.889
		Contractor	0.215	0.167	0.402
	Contractor	Architect	−0.277	0.158	0.187
		Civil engineer	−0.215	0.167	0.402
IM53	Architect	Civil engineer	−0.043	0.131	0.943
		Contractor	0.052	0.155	0.939
	Civil engineer	Architect	0.043	0.131	0.943
		Contractor	0.095	0.164	0.830
	Contractor	Architect	−0.052	0.155	0.939
		Civil engineer	−0.095	0.164	0.830

Table A1.

(*continued*)

Dependent variable	(I) Profession	(J) Profession	Mean difference (I−J)	Std. error	Sig.
IM54	Architect	Civil engineer	0.513*	0.139	0.001
		Contractor	0.805*	0.165	0.000
	Civil engineer	Architect	−0.513*	0.139	0.001
		Contractor	0.292	0.174	0.216
	Contractor	Architect	−0.805*	0.165	0.000
		Civil engineer	−0.292	0.174	0.216
IM55	Architect	Civil engineer	0.366*	0.142	0.028
		Contractor	0.866*	0.168	0.000
	Civil engineer	Architect	−0.366*	0.142	0.028
		Contractor	0.500*	0.177	0.014
	Contractor	Architect	−0.866*	0.168	0.000
		Civil engineer	−0.500*	0.177	0.014
IM56	Architect	Civil engineer	0.234	0.139	0.214
		Contractor	0.763*	0.164	0.000
	Civil engineer	Architect	−0.234	0.139	0.214
		Contractor	0.529*	0.173	0.007
	Contractor	Architect	−0.763*	0.164	0.000
		Civil engineer	−0.529*	0.173	0.007
IM57	Architect	Civil engineer	0.341*	0.134	0.032
		Contractor	0.760*	0.159	0.000
	Civil engineer	Architect	−0.341*	0.134	0.032
		Contractor	0.419*	0.168	0.035
	Contractor	Architect	−0.760*	0.159	0.000
		Civil engineer	−0.419*	0.168	0.035
IM58	Architect	Civil engineer	0.151	0.138	0.518
		Contractor	0.575*	0.163	0.001
	Civil engineer	Architect	−0.151	0.138	0.518
		Contractor	0.424*	0.172	0.039
	Contractor	Architect	−0.575*	0.163	0.001
		Civil engineer	−0.424*	0.172	0.039
IM59	Architect	Civil engineer	0.058	0.142	0.913
		Contractor	0.116	0.168	0.768
	Civil engineer	Architect	−0.058	0.142	0.913
		Contractor	0.058	0.178	0.942
	Contractor	Architect	−0.116	0.168	0.768
		Civil engineer	−0.058	0.178	0.942

Note(s): *The mean difference is significant at the 0.05 level

Table A1.

Corresponding author
Gulden Gumusburun Ayalp can be contacted at: gulden.ayalp@hku.edu.tr