1 Introduction to secondary research methods in the built environment

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Introduction

Secondary research methods involve the analysis of data that already exists or has already been created. This is in contrast to primary research, which is based on principles of the scientific method (Driscoll, 2011) where researchers learn more about the world by collecting measurable data first-hand. In recent years, the use of secondary research methods has grown exponentially across various disciplines, including in the built environment. This growth has been attributed to technological advances (Johnston, 2014) and the vast amounts of secondary data that is now available and easily accessible for research as a result. Researchers and students at both undergraduate and postgraduate levels across various built environment disciplines, including their academic instructors, are increasingly recognising and exploiting the immense opportunities in conducting secondary research. However, for the inexperienced secondary researcher, some of the issues with which they are confronted include clarifications to questions such as: what exactly is secondary research? What types of secondary research methods are available, and how can these methods be applied robustly in built environment research? This is hardly surprising as issues relating to secondary research can be confusing for experienced researchers who are unfamiliar with secondary research methods, let alone the novice researcher. This situation has been complicated by the sometimes differing views and varying terminologies that are used to describe different secondary research methods. Terminologies, such as secondary data analysis, qualitative secondary analysis (QSA), qualitative secondary research, meta-analysis, and meta-synthesis, abound in the literature without clarity on how all these fit within the domain of secondary research methods.

Therefore, in this introductory chapter, the aim is to create a context for the rest of this book by evaluating what constitutes secondary research, the secondary research process, secondary research designs and the benefits and drawbacks of applying secondary research methods in built environment research. To conclude, an overview of the various chapters that are included in this book has been presented.

What is secondary research?

Secondary research involves the use of data that already exists rather than what would be obtained from first-hand sources, using primary methods such as questionnaires, interviews, focus groups, observations, and the like. Johnston (2014, p. 619) who used the term "secondary data analysis" defined this as "the analysis of data that [were] collected by someone else for another primary purpose".

There are subtle differences in perspectives as to what constitutes secondary research. In some discussions the re-analysis of data from previous primary research is emphasised, suggesting that all forms of secondary research will utilise data that have emerged from a primary research study, which have been analysed and published in academic literature, but are then being re-analysed. However, in the definition offered by Johnston (2014), the term "analysis" is used rather than "re-analysis", an indication perhaps that the data for secondary analysis might be in its raw state but would still have come into existence for a different purpose. Whilst some secondary methods are focused on the re-analysis of published findings from primary research (e.g. systematic literature reviews (SLRs) and meta-analysis), confining secondary research to only the use of such methods is a narrow perspective. This is because there are other established secondary research methods such as the QSA that involve the re-use of archived, original (pre-existing) qualitative data (e.g. interview transcripts) to answer new research questions. The raw qualitative data would have been archived in their original, pre-analysed, and unpublished form and, hence, their re-use as secondary data is a case of re-purposing the original data. With this practice, the existing unanalysed and archived, raw data are re-used as opposed to re-analysing the published results from a previous analysis of the same data.

Johnston (2014) also emphasised in his definition that the existing data should have been collected by someone else rather than the secondary researcher. This relationship between the secondary researcher and how the existing data came about has also featured in other discussions on secondary research. Church (2001), for instance, emphasised that in secondary data analysis, individuals that were not involved in data collection are responsible for analysing the data, unlike in primary research where individuals that collect the data are also responsible for analysing it. This suggests that secondary research will always involve the use of data that have been collected by someone else, which is mostly the case. However, it is important to clarify also that secondary research can involve the re-use of existing raw data that had previously been collected by the same individuals, although for a different purpose than their re-use to explore new research questions (Ruggiano and Perry, 2019).

From a much broader perspective, secondary research can also extend beyond the re-use or re-analysis of data from previous primary research, although the purpose of the data's existence should be different from the purpose of their present use in research. Secondary research can encompass the analysis of existing datasets that might not have come about from primary research (Doolan *et al.*, 2017). Doolan *et al.* (2017), whose work was done from a medical research perspective, emphasised that existing datasets for secondary research can also be derived from

other sources such as hospital charts, academic course records, quality improvement records, news media, or social media. What is clear from the various perspectives is that secondary research: (1) involves the use of pre-existing datasets, and (2) these datasets should have come into existence for purposes that are different from the purpose of their use in the secondary research. This view is consistent with the meaning of the term "secondary" in secondary research, which refers to the use of pre-existing data for secondary analysis. The term indicates only that the data are being used for research purposes beyond the specific need that prompted their original gathering or its generation (Stewart and Kamins, 1993).

The term "research" refers to the application of a systematic approach to study and generate new facts and conclusions about a subject of interest. Put together, a broader definition of "secondary research" is the study of specific problems to generate new facts and conclusions through analysis of pre-existing data or information that was originally created for a different reason or purpose.

It is from this broader perspective of secondary research that the rest of this book has been compiled. Based on this broader perspective, it should be emphasised once again that the pre-existing data or information may or may not have come about from primary research but should still meet the requirement of existing for a different purpose than their use in secondary research. The systematic approach that should be applied when conducting secondary research requires that a clear, logical, transparent, and verifiable process is followed.

Secondary research process

Despite the increase in the use of secondary research methods, there is still limited guidance on what this process should entail (Doolan *et al.*, 2017), and practical case examples that outline the process and techniques required to carry out secondary research effectively are lacking, particularly within the context of the built environment. However, it should be clarified that one of the main features that differentiates the secondary research process from the primary research process relates to data collection and analysis as shown in Table 1.1.

The steps involved in the secondary research process are discussed briefly below.

Table 1.1 Comparison of secondary data and primary data research processes

Secondary research	*Primary research*
Establish gaps in the research and formulate research questions using existing literature	Establish gaps in the research and formulate research questions using existing literature
Undertake a detailed literature review	Undertake a detailed literature review
Identify, select, and evaluate the existing datasets	Develop data collection instruments and protocol and collect data
Undertake secondary data analysis	Undertake primary data analysis
Discuss, interpret, and disseminate findings from the research	Discuss, interpret, and disseminate findings from the research

Source: Adapted from Doolan *et al.* (2017) and Johnston (2014).

Establish gaps in the research and formulate research questions

Just like with primary research, it is important that secondary research commences with a literature review to establish the research gaps, and research question(s) or hypotheses. Clearly defined research question(s) or hypotheses will be crucial in establishing whether the study will fit well with any existing dataset (Smith, 2008).

Undertake literature review

At this stage of the secondary research process, literature will need to be reviewed to examine the current and past thoughts and issues in the area of interest (Johnson, 2014). This is still the case even when the secondary method to be used involves the re-analysis of published academic literature as secondary data e.g. a systematic literature review.

Identify, select, and evaluate the existing datasets

It is important to ascertain whether the existing dataset can address the research question of the secondary study (Long-Sutehall *et al.*, 2010; Johnson, 2014). If the datasets are from previous primary research, it is essential that the purpose for which they were collected originally – the data collection techniques and instruments used and the participants from which the data were collected – are all established as part of the evaluation (Smith, 2008).

Undertake secondary data analysis and disseminate findings

Data analysis forms an integral aspect of any research methodology. It is essential that the analysis and the interpretation of the findings are undertaken in the same way as the methods used for the primary data research (Long-Sutehall *et al.*, 2010).

Secondary research designs

Just as in primary research, secondary research designs can be either quantitative, qualitative, or a mixture of both strategies of inquiry (qualitative and quantitative) as shown in Figure 1.1. Qualitative secondary research designs can be based on either the re-analysis of published results or the analysis of existing qualitative datasets. Largan and Morris (2019, p. 14) defined qualitative secondary research as "a systematic approach to the use of existing data to provide ways of understanding that may be additional to or different from the data's original purpose". There are various qualitative, secondary research methods. Those that are based on the re-analysis of published academic literature include SLRs or meta-synthesis, state-of-the-art reviews and scoping reviews. SLRs have been discussed in detail in Chapters 5–7 of this book. Qualitative secondary research can also be based on
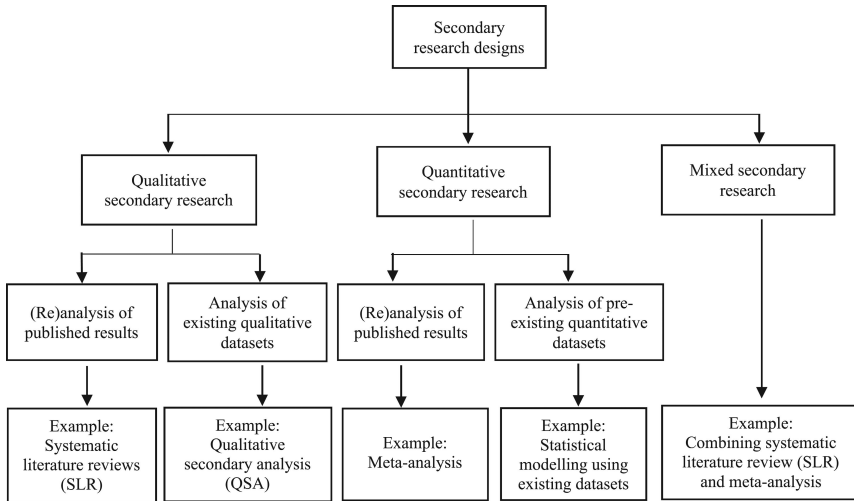
Figure 1.1 Secondary research designs.
Source: Original.

designs that involve the analysis of existing raw qualitative datasets rather than the published results from a previous analysis. A typical example of such a design is the QSA, which involves the use of pre-existing qualitative data from primary research to develop new social scientific or methodological understandings (Heaton, 2008; Irwin, 2013). According to Johnston (2014), using QSA contributes to scientific knowledge by offering alternative theoretical or conceptual perspectives on previously collected and archived qualitative data. QSA has been discussed in detail in Chapter 4 of this book.

There are other qualitative designs like legal research that arguably straddle between the primary and secondary research domain, depending on whether the sources of data used for the analysis are regarded as primary or secondary sources of the law. For example, the analysis of legal trends and principles using secondary sources of law, such as law reports, legal commentaries, and other literature about law, will constitute a form of secondary qualitative research. The secondary dimension of legal research, and more specifically doctrinal legal research, has been discussed in detail in Chapter 8 of this book.

Similarly, on the quantitative secondary research side, designs can involve the re-analysis of published academic literature or the analysis of pre-existing quantitative datasets. A typical example of a quantitative secondary research design that is based on published results is quantitative secondary analysis, which is a quantitative form of systematic review that is commonly referred to as meta-analysis research. This is a very well-established secondary research design in which statistical approaches are used to combine quantitative research findings from multiple empirical studies to increase the analytical power owing to the combined effect

of sample sizes from the various studies. Church (2001) described meta-analysis as the quantitative combination of statistical information from multiple studies on a given phenomenon. Meta-analysis has been applied in Chapter 15 of this book.

Another secondary design that is more quantitative in nature and which is growing in popularity in the built environment is bibliometric research. Bibliometric research or analysis and its sub-approaches, such as scientometric research or science mapping, are alternative quantitative approaches to SLRs and are used to synthesise various trends from published academic literature. Bibliometric research involves the analysis of quantitative patterns relating to a cluster of scientific documents within a given domain (De Bellis, 2009) through the computation of quantitative metrics from published academic literature. The analytical methods that are used in bibliometric research include co-author analysis, co-citation analysis, and keyword analysis. Bibliometric research and its sub-approaches, such as scientometric research, have been presented in Chapters 9–13, including case examples that reflect their growing popularity across various built environment disciplines.

Literature-based discovery (LBD) is another less known method also on the quantitative spectrum that can be used to synthesise results from published academic literature. This method involves the use of statistical procedures to deduce relationships and hypothesis from published academic literature by computing semantic measures. LBD has been discussed in detail in Chapter 14.

The secondary quantitative research designs that are based on analysis of pre-existing quantitative datasets involve the use of statistical techniques to analyse different trends in the data. Such techniques include statistical modelling and the application of big data analysis techniques to existing datasets. These techniques could also involve the re-use of quantitative data from previous primary research by applying different statistical analysis to generate different insights.

Secondary research can be based on a mixed design, whereby a mixture of secondary qualitative and secondary quantitative approaches is applied in a study. For example, this could be the application of SLRs and bibliometric reviews or SLRs and meta-analysis, the latter of which has been demonstrated in Chapter 15 of this book. In Chapter 15, Low-Choy *et al.* advocate a mixed approach to meta-analysis research (qualitative and quantitative). An example of a mixed secondary design that utilises existing quantitative and qualitative datasets is also presented in Chapter 16. This chapter is used to demonstrate the potential in using existing datasets, collected as part of previous research, to answer new research questions, having ensured the suitability of the existing data for the new studies. It should be noted that the secondary research designs discussed in this chapter are not exhaustive, but that the focus has been mainly on methods that have been covered in this book.

It is evident from the discussions and from Figure 1.2 that the process that should be followed when designing secondary research is similar to that of primary research. This decision-making process involves a reflection on the philosophical assumptions underpinning the study (positivist or interpretivist), which should inform the
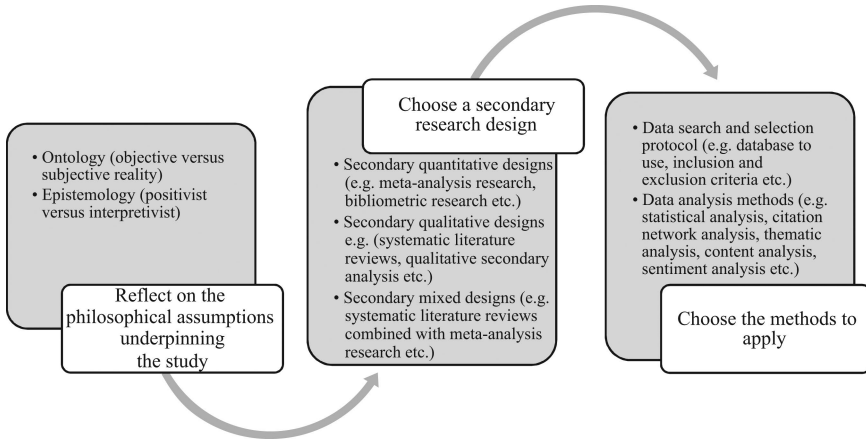
Figure 1.2 Framework to guide decision-making when designing secondary research.
Source: Original.

choice of the research design (meta-analysis research, bibliometric research, SLR and so on) and the research methods (thematic analysis, content analysis, citation network analysis and so on). Although these philosophical considerations might be hidden in the decision-making process, they still influence the choices that are made in terms of the research strategy and the methods that are adopted for organising and analysing the secondary data. As an example, in a SLR study that is aligned to an interpretivist perspective, thematic analysis would be selected as the method of data analysis as opposed to content analysis (see Chapter 6).

Potential for applying secondary research methods in the built environment

There is considerable potential to apply both qualitative and quantitative secondary research methods across various built environment disciplines. Research students in the fields of construction management, construction project management, quantity surveying, construction law and dispute resolution, real estate and property management, and civil engineering can apply secondary qualitative or quantitative methods that are based on either re-analysis of published academic literature or re-use of pre-existing raw datasets.

To date, there has been a significant increase in the use of methods that are based on published academic literature, such as SLRs, and bibliometric research. There have also been some applications of meta-analysis research in built environment research. For example, Alruqi and Hallowell (2019) performed a statistical meta-analysis of leading indicators of construction safety by combining the results of various studies to increase the magnitude of effect and significance of the findings. However, there is scope for increased use of

meta-analysis research as a quantitative approach for synthesising results from already published results. There is also potential for the application of secondary methods such as scoping reviews, state-of-the-art reviews and LBD, which are also based on the re-analysis of published academic literature, but have not been exploited fully in built environment research.

Another area that offers significant potential, and which remains largely unexploited, is the re-use of pre-existing, archived, qualitative data to conduct QSA. Whilst this approach has become increasingly well established in mainstream social science disciplines, there is a need for awareness of this potential. There is also a need for the necessary infrastructure within built environment disciplines such as construction management that can enable sharing and archiving of original data from qualitative primary research so that these can be re-used as secondary data. Opportunities to utilise pre-existing qualitative datasets (e.g. social media data) and quantitative datasets that are not necessarily a result of previous primary research will also continue to grow with the increasing availability of such datasets and the advancements in data mining and big data analytic techniques that make it easier to explore trends in these datasets. Despite the potential and advantages of utilising secondary research methods in the built environment, there are also potential challenges and drawbacks.

Benefits and drawbacks of applying secondary research methods

Secondary research methods can offer a range of benefits in built environment research, but are not without drawbacks. The benefits of using secondary research methods include the following. The methods:

- are comparatively quicker than primary research and can save time;
- are less expensive than primary research;
- can offer possibilities to study topics that are too sensitive to undertake by engaging first-hand with people and institutions;
- can enhance the scale of research that can be conducted even with time and resource constraints;
- can help to prevent respondent fatigue, which is a usual occurrence with primary data collection as participants become tired of completing questionnaire surveys or participating in interviews.

The earlier advantages reflect the views of Johnston (2014), which are that secondary research can be quicker, more cost-effective, and convenient, allowing for analysis of larger datasets that are more representative of the target population, and ensuring that higher levels of validity and more generalisable findings are achieved. However, it should be noted that, in some instances, secondary data might be available at a cost (e.g. on subscription basis). Also, contrary to the view that using secondary research can be quicker, it could take a considerable amount of time to transform into a format required for the analysis. This raises some

of the challenges and drawbacks associated with the application of secondary research methods for built environment research, which include the following:

- The data might not be available in the format required for analysis, thus requiring considerable time and effort to transform;
- The available data might not necessarily be appropriate for answering the research questions of interest for the secondary research;
- Methodological challenges could result from the use of inappropriate data analysis methods, leading to misinterpretation of the original data;
- There also might not be enough contextual information about the data to enable accurate interpretation of the findings.
- The realities at the time when the original data came into existence might not be the same as the realities during the period of secondary analysis, raising an issue about the timeliness of the data;
- In instances where the secondary research utilises data from previous, primary research, the secondary researcher might not be privy to the problems or weaknesses associated with the collection of the primary data as, in most instances, they would not have been part of that process;
- There might be missing sections in the existing datasets (e.g. missing datasets in time-series data) that might be difficult to extrapolate with accuracy.

Despite the potential as well as considerable opportunities for applying secondary research methods in built environment research, it is evident from the challenges and drawbacks listed earlier that there are also pitfalls and limitations that should be considered carefully. The application of secondary research methods might not necessarily be appropriate for the research questions of interest. It will be necessary for built environment researchers, who are interested in applying secondary research methods, to be aware of these pitfalls and limitations so that they can make the best decisions about whether to apply secondary research methods in the first place.

Overview of chapters

This book comprises 16 chapters which are outlined below.

In Chapter 1, Introduction to Secondary Research Methods in the Built Environment, Emmanuel Manu and Julius Akotia present discussions on what constitutes secondary research before reflecting on the secondary research process, secondary research designs, and the potential for applying secondary research methods in built environment research. The benefits and drawbacks of applying secondary research methods also have been reflected upon. The purpose of this chapter was to provide the context for all the other chapters in the book.

In Chapter 2, Identifying and Sourcing Data for Secondary Research, Emmanuel Manu, Julius Akotia, and Saad Sarhan distinguish between secondary data and primary data, whilst acknowledging the sometimes blurred and confusing nature of this distinction. The sources of secondary data that are applicable to

various built environment disciplines have also been identified and discussed. These include academic databases, government databases, intergovernmental databases, organisational databases, legal databases, and social media data. The opportunities for utilising data from these various sources have been interrogated. Manu *et al.* also reflect on some of the considerations that will need to be exercised to ensure that the pre-existing datasets are of the right quality for use in secondary research.

In Chapter 3, Ethical Considerations in the Use of Secondary Data for Built Environment Research, Abid Hasan evaluates the ethical considerations that must be exercised when using secondary data for research. In this chapter, the main ethical issues that must be considered as part of the research design – data collection and analysis, data storage and disposal, and dissemination of the findings – when using secondary datasets are addressed. Just as with primary research, Hasan makes it clear that the research protocol for secondary data research should address the questions regarding how the existing data will be collected, analysed, kept anonymous, published, stored, and secured. By drawing on the three Belmont principles of autonomy (respect for persons), beneficence, and justice, Hasan ends with advice that researchers using secondary data should ensure that sampling protocols and data collection procedures are established, the source and ownership of the original data is acknowledged, information about the original data (e.g. the response rate, sampling bias, missing data, and the time data came into existence) is reported, and that effective methods of securing the anonymity of the data are used to report the findings of the secondary research.

In Chapter 4, Qualitative Secondary Analysis as a Research Methodology, Victoria Sherif provides a historical overview of QSA as a research methodology. Epistemologically, Sherif highlights the systematic, subjective and yet highly reflexive process of QSA as the researcher explores pre-existing qualitative data for new meanings relating to human experiences within a social context. This reflexive process, which should account for the background context of the original data, has the potential to generate more meaningful empirical and/or methodological findings.

Methodologically, Sherif highlights the extensive preparatory and evaluative work that is required to address the research objectives adequately and meaningfully when applying QSA. It is also advised that QSA should be applied as a methodological approach for generating new knowledge or broadening understanding of a topic of interest, to enable a new research study or data collection or to use as a discrete method. Sherif also advises that the fit and relevance of the dataset, general quality of the dataset, trustworthiness of the dataset, and timeliness of the dataset are considerations that should be exercised before selecting existing data for QSA. Whilst this chapter is focused on the social and educational context, it offers insight into the application of QSA as a methodology in built environment research.

In Chapter 5, Evaluation of Systematic Literature Reviews in Built Environment Research: What are We Doing and How Can We Improve?, Vijayan Chelliah, Nicola Thounaojam, Ganesh Devkar, and Boeing Laishram introduce

the SLR technique by reflecting on five primary steps of the SLR process comprising: formulate the research question, locate the literature, select and evaluate the literature, analyse and synthesise the studies, and report the review results. They offer important advice on how to formulate concise research questions for SLRs using different frameworks, how to locate the literature using appropriate search strings, the inclusion and exclusion criteria for selecting and evaluating the literature, some standardised questions for analysing and synthesising the findings, and approaches and procedures for reporting the results. Chelliah *et al.* also evaluate how these five stages of SLR have been applied in built environment research, based on which they have identified areas of improvement. Based on this evaluation, they have provided a very useful checklist for improving the quality of SLR studies in the built environment.

In Chapter 6, When Does Published Literature Constitute Data for Secondary Research and How Should the Data be Analysed?, Saad Sarhan and Emmanuel Manu discuss the use of published academic literature for both traditional literature reviews in research as well as for secondary data when applying qualitative secondary research methods, such as SLRs, scoping reviews, state-of-the-art reviews, or quantitative secondary research methods such as bibliometric reviews and meta-analysis. Sarhan and Manu then focus on the details of SLR as a qualitative secondary research method, based on which they discuss thematic analysis and qualitative content analysis as the main methods for analysing qualitative secondary data, with a focus on using computer-assisted, qualitative data analysis software such as NVivo to support this process. Specific guidance on when and how to use NVivo for supporting qualitative SLRs is also presented. This chapter, therefore, contains methodical guidance on how to conduct SLRs of existing academic literature, using NVivo – an approach which can also be applied to other qualitative secondary research methods.

In Chapter 7, A Systematic Literature Review Evaluating Sustainable Energy Growth in Qatar Using the PICO Model, Redouane Sarrakh, Suresh Renukaappa, and Subashini Suresh illustrate the use of the PICO Model for SLRs with an example of a study that evaluates sustainable energy growth in Qatar. This chapter includes a case example of the application of SLRs following the PICO Model in built environment research, based on a case study about the efficiency of policies and tactics implemented by the Qatari Government in its energy sector, pertaining to sustainability strategies. Initial results using the PICO Model led to the identification of 1990 resources from five different databases, of which 82 met the pre-set inclusion and exclusion criteria, such as date, geographic location, language, type of publications, participants, and design studies. From the SLRs, Sarrakh *et al.* were able to map the Qatar Energy Sector to six sustainability initiatives, namely: health and safety, environment, climate change and energy, economic performance, society, and workforce. Sarrakh *et al.* concluded that Qatari sustainable development policies still needed great efforts to achieve more holistic policies and more integrated and comprehensive strategies.

In Chapter 8, Understanding Legal Research in the Built Environment, Joseph Mante discusses legal research as an approach that employs both primary and

secondary sources of data to arrive at logically sound outcomes. Mante argues that within the built environment, legal research is often undervalued or even mischaracterised as a tool for preliminary enquiry. These misconceptions stem from lack of understanding of the province of legal research in the built environment and the procedures involved. This misunderstanding is dispelled in this chapter by explaining the scope and the procedures involved in legal research, with doctrinal legal research being a dominant aspect. In its basic form, legal research involves locating, describing, interpreting, and systematising legal principles and concepts, with the legal system as a conceptual framework. The resources for this exercise are primary data (legislations) and secondary data (e.g. law reports, legal commentaries, and other literature about the law), and the outcomes are supported and based on sound reasoning.

In Chapter 9, Applying Science Mapping in Built Environment Research, Amos Darko and Albert Ping-Chuen Chan discuss science mapping as an effective and useful methodology for studying and understanding the structural and dynamic features of a scientific domain through constructing, analysing, and visualising bibliometric networks. Darko and Chan discuss the application of science mapping in built environment research before providing a step-by-step tutorial on how three software packages, VOSviewer, CiteSpace, and Gephi, can be applied together to conduct robust science mapping-based research. This chapter will be helpful to researchers and other interested stakeholders that intend to undertake quality research using science mapping.

In Chapter 10, Bibliometric Analysis for Reviewing Published Studies in the Built Environment, Liyuan Wang, Ruoyn Jin, and Joseph Kangwa define bibliometrics analysis before reflecting on the rationale for adopting this method when conducting literature reviews. The existing software tools for conducting the text mining-based analysis (e.g. VOSviewer, Gephi) also are introduced. Using two case examples from disciplines in the built environment, Wang *et al.* illustrate the science mapping workflow that is involved in bibliometric analysis, based on which Wang *et al.* showcase the network analysis with one of the bibliometric analysis tools (i.e. VOSviewer). Finally, general guidance that should be observed when conducting bibliometric analysis is provided, with some concluding recommendations on the common mistakes that should be avoided when conducting bibliometric analysis.

In Chapter 11, Scientometric Review and Analysis: A Case Example of Smart Buildings and Smart Cities, Timothy O. Olawumi, Abdullahi B. Saka, Daniel W.M. Chan, and Nimesha S. Jayasena present the scientometric analysis process as a quantitative study of the intellectual evolution of research themes based on large-scale datasets before presenting a case example of this method using a study on smart buildings and smart cities. Using this example, Olawumi *et al.* reflect on simplified steps that should be followed when conducting scientometric analysis, addressing issues such as sources of data for the "smart buildings and smart cities" research theme, software tools that can be utilised, and the analysis that can be performed to identify trends using the citation data such as analysis of co-author network, co-occurring keywords, author co-citation network, and

document co-citation network. The case example serves as a useful guide for built environment researchers who are interested in applying scientometric analysis to other emerging research themes.

In Chapter 12, Analysis of BIM-FM Integration Using a Science Mapping Approach, Ecem Tezel and Heyecan Giritli present another case example on science mapping, using a study on building information modelling (BIM) and facility management (FM). Through this case example, they demonstrate the application of a three-step, science mapping approach to the BIM and FM knowledge domain. These three steps comprise a bibliometric search of the journal articles published in the Web of Science and Scopus databases, followed by scientometric analyses of the journals using VOSviewer software to identify the most influential journals, authors, and keywords in the BIM-FM domain, before finalising the third step, which is an in-depth qualitative discussion to summarise the present knowledge in BIM-FM integration and to propose future research directions. Through this case example, Tezel and Giritli demonstrate the application of three analytical domains for science mapping studies, namely journal analysis, scholar analysis, and keyword analysis.

In Chapter 13, Trends in Recycled Concrete Research: A Bibliometric Analysis, Olalikan Shamsideen Oshodi and Bankole Osita Awuzie present a case example of a bibliometric study. The aim is to detail the research trends and gaps associated with material circularity of concrete to identify knowledge gaps and future research directions. The topic of material circularity has been attracting attention from the construction industry stakeholders that are keen to overcome the industry's negative impacts on sustainability and, since concrete is an intensively utilized resource in the construction industry, Oshodi and Awuzie chose a bibliometric analysis as a method for establishing the research trends on circularity of concrete as a construction material, whilst highlighting gaps necessitating further study using recycled concrete. This bibliometric method allowed for the identification of the growth in rate of publications within the review period, the most productive authors working within the knowledge domain area, degree of collaboration between them, author distribution, collaboration networks, institutions and countries producing such publications, and the journals where such articles were published. The example presented in this chapter can provide guidance for construction management researchers who are interested in applying bibliometric analysis.

In Chapter 14, Using Literature-Based Discovery in Built Environment Research, Nathan Kibuwami and Apollo Tutusigensi introduce a secondary research method called LBD, which involves the identification of novel relationships and/or theories from two or more disparate contexts of literature. With origins in biomedical research, LBD is used to search for novel hypotheses in the literature, using either an open discovery or closed discovery approach. Kibuwami and Tutusigensi argue that there has been very limited application of LBD in built environment research despite the potential it offers, with some built environment researchers apparently confusing this method with other literature-related approaches such as SLRs. Kibuwami and Tutusigensi continue to advocate the development of a

robust understanding of LBD among built environment researchers in order to increase its use. They achieve this by proposing a five-step approach to implementing LBD, which involves literature data retrieval; term extraction; category development; semantic similarity; and deduction of relationships. This five-step approach is applied using a case example to demonstrate how the core principles of LBD can be upheld.

In Chapter 15, Combining Study Findings by Using a Multiple Literature Review Technique and Meta-Analysis: A Mixed Method Approach, Samantha Low-Choy, Fernando Almeida, and Judy Rose discuss the meta-analysis research process before presenting two inter-disciplinary case examples of meta-analysis research. They adopt a mixed approach to meta-analysis research that commences with a structured literature review (scoping and then SLR) to select studies that are used to perform the meta-analysis research, clarifying eligibility via qualitative, narrative or model-centric review, and ending with a realist review. The AMSTAR2 appraisal tool is applied to a seven-staged process for conducting meta-analysis studies, which Low-Choy *et al.* then apply to two, non-randomised case studies. The guide they provide to performing meta-analysis research is based on AMSTAR2, which is a meta-analysis appraisal tool for appraising the quality of published systematic reviews for meta-analysis. Low-Choy *et al.* suggest that viewing meta-analysis as a mixed (quantitative and qualitative) method provides a wider array of options and is more suitable in many fields, especially multidisciplinary fields such as built environment. Through these two case examples, Low-Choy *et al.* provide a forward-looking guide for researchers who will be interested in conducting meta-analysis research using observational data, which is the type of data that is prevalent within built environment disciplines such as construction management.

In Chapter 16, Analysing Secondary Data to Understand the Socio-Technical Complexities of Design Decision Making, Payam Pirzadeh, Helen Lingard, and Nick Blismas present a secondary research study that involved the selection and re-analysis of six case studies from an existing comprehensive dataset. The existing dataset included 23 case studies, each of which was focused on the building-design process of a structural element. This existing dataset had come about from a study that had a different purpose of understanding in which characteristics of communication between participants in the design process were linked to positive health and safety (H&S) outcomes. The aim of the new, secondary research study was to reveal the interdependence between social and technical aspects of construction-design decision-making and explain the impact on constructability and H&S outcomes by building on and extending the findings of the previous research. To select six of the existing cases for re-analysis, Pirzadeh *et al.* developed and used a set of selection criteria to ensure the suitability of the secondary data for the new study. Pirzadeh *et al.* then applied a secondary, convergent, mixed methods design that was combined with a novel, multi-level network analysis framework to integrate and analyse the existing, quantitative, and qualitative data for each case simultaneously. Consequently, a more comprehensive and detailed investigation of the socio-technical complexities that characterise

construction-design decision-making was achieved in the new study. To demonstrate this approach, the results of only one of the case studies have been reported in Chapter 16. Opportunities for employing new research designs and novel methods to re-analyse existing datasets, collected as part of previous research, to answer new research questions are indicated in the chapter. The importance also of ensuring the suitability of the existing data for new studies is highlighted.

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