TRANSFORMING EXISTING URBAN HOUSING ESTATES INTO AGE-FRIENDLY COMMUNITIES IN CHINA: A MULTI-AGENT PLATFORM FOR THE BRIEFING STAGE

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Transforming Existing Urban Housing Estates into Age-friendly Communities in China: A Multi-agent Platform for the Briefing Stage

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

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ABSTRACT

Rapid ageing has become one of the biggest global challenges in the 21st century and has urged urbanised cities to make changes accordingly. On the global scale, making cities and communities age-friendly will facilitate the achievement of sustainable development goals of the *World Health Organisation* (WHO) and allow cities and communities to be developed into inclusive and equitable places in which vulnerable groups, such as senior citizens, can live. Age-friendly cities and communities will benefit everyone in the near future. For developing countries like China, promoting age-friendly communities (AFCs), especially through the transformation of existing urban housing estates, is critical because the issues of medical care, welfare system and urban-rural integration have not been substantially addressed.

Numerous efforts have been made to construct AFCs in China by national, regional and local organisations during the past few decades, and in 2016, *China National Committee on Ageing* put forward guidelines on promoting an age-friendly built environment that set forth the basic principles, developing goals, major tasks and supporting measures for the development of AFCs. Despite these efforts, limited attention has been paid to key stakeholders' concerns on critical success factors (CSFs) for AFC projects at the beginning. To transform existing urban housing estates into AFCs in China, efficient cooperation from many parties is needed, including from

governments, service providers, civil societies and senior citizens. Given that no detailed guidelines have yet been proposed regarding stakeholders' involvement and responsibilities, it is not clear which sector will be actively involved, which stakeholder will be responsible for the construction work, and whose interests should be given the highest priority when conflicts occur. In addition, the question of how effective key stakeholder collaborations should be promoted has not received sufficient consideration.

Therefore, this research aims to examine whether a multi-agent platform (MAP), on which key stakeholders' relationships and their concerns on CSFs are taken into consideration, can support the briefing stage of AFC projects in urban China. The research objectives are accomplished by carrying out Delphi-panel screenings to identify key stakeholders and CSFs extracted from the literature review and document analysis on studies related to AFCs, conducting focus group discussions among key stakeholders of AFC projects, establishing a two-mode social network to analyse the relationships, and applying agent-based modelling techniques to explore mitigating strategies to deal with conflicts among key stakeholders.

This study makes original contributions to the knowledge of AFCs and the briefing stage of construction projects. First, a roadmap is developed to identify critical AFC research areas, key stakeholders and CSFs for AFC projects. Second, key stakeholders'

concerns on CSFs during the briefing stage of AFC projects are explored. The importance of fostering effective collaborations by analysing key stakeholders during the briefing stage is emphasised. Moreover, a three-tiered MAP is proposed to help address conflicts among key stakeholders during the briefing stage of AFC projects.

The findings of this study can also support practical AFC projects: Practitioners can follow the proposed framework to explore the relationship among key stakeholders during the briefing stage of AFC projects. It is suggested that key stakeholders make changes in the identified challenges of AFC projects in urban China. Moreover, practitioners can apply the MAP to better understand the participating stakeholders and to explore strategies to mitigate conflicts.

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Journal Papers:

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Xiang, L., Yu, T., Tan, Y., Jin X., and Shen, G., 2020. Understanding stakeholders' concerns of age-friendly communities at briefing stage: A China study. In: Y. Wang, T. Olofsson and G.Q.P. Shen, eds. *Intelligent Construction and Sustainable Buildings: Proceedings of the International Conference on Construction and Real Estate Management 2020*, 24-25 August 2020, Stockholm. Reston: American Society of Civil Engineers, pp.639-650.

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CHAPTER 1 INTRODUCTION

1.1 Research Background

1.1.1 Population Ageing and Global Age-Friendly Cities Project

Rapid ageing and urbanization, as two historically significant demographic shifts, have affected the whole world since the beginning of the 21st century. According to the *World Health Organisation* (WHO), approximately one million people turn 60 every month worldwide (WHO, 2019). As the older population continues to grow dramatically, age-friendly developments are urgently required. With more than 20% of the global population predicted to be 60 years old or over by 2050 (United Nations et al., 2017), there will be an increasing need for age-friendly cities with policies, services and structures that are designed to support seniors' in their daily lives.

As major urban centres have the social and economic resources to make cities more age-friendly and can therefore set examples for other cities to follow, together with the fact that three-quarters of older persons live in cities in the developed world (WHO, 2019b), one of the most effective approaches in response to the rapid demographic ageing is thus to make cities age-friendly. Although more seniors in developing countries live in rural areas than in developed countries, rapid urbanisation

is gradually changing the whole picture as urban areas continue to expand and people continue to move to such areas to live.

Building on the *Active Ageing Framework* that was introduced in the early 2000s, and after hosting focus group discussions in 33 developed and developing cities across the world, in 2007, the WHO proposed the *Vancouver Protocol*, a framework for assessing age-friendliness. Eight major areas of focus (Figure 1-1) for municipalities were outlined in the *Vancouver Protocol*. These eight aspects of city life overlap and interact with the determinants of active ageing; initial checklists related to each area were also created in the *Vancouver Protocol* (WHO, 2007a, b).

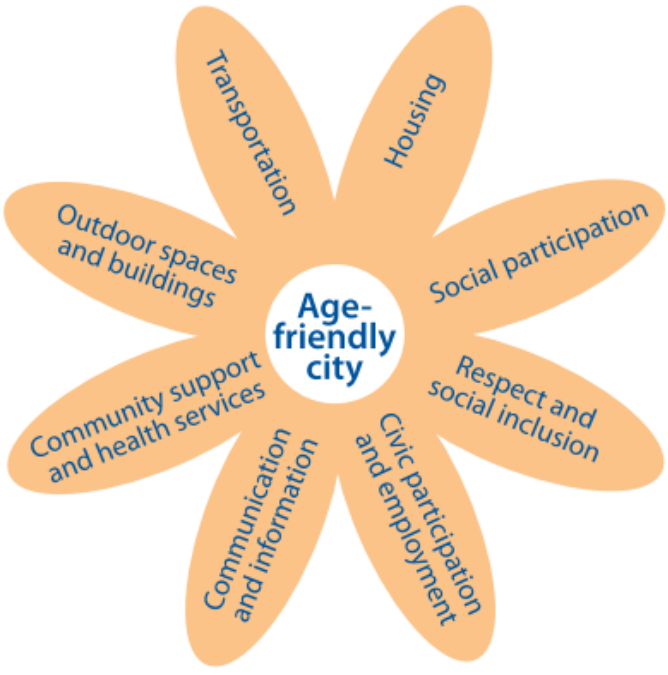


Figure 1-1 Eight Major Areas of an Age-Friendly City (WHO, 2007a)

Today, increasing attention is being paid to the environmental and social factors that contribute to active ageing in urban settings. With the aim of engaging as many cities as possible to make their communities more age-friendly, the WHO's *Global Age-Friendly Cities* project focuses on the 'lived' experience of senior citizens. As a method to connect cities, communities and organizations worldwide, the *Global Network for Age-friendly Cities and Communities (Global Network)* was established by the WHO in 2010, and 700 members have already joined the network. For cities and communities that wish to join the *Global Network*, a five-year cycle that involves four stages (Figure 1-2) is required to commit, and the WHO emphasises the importance of senior citizens' active participation in the process.

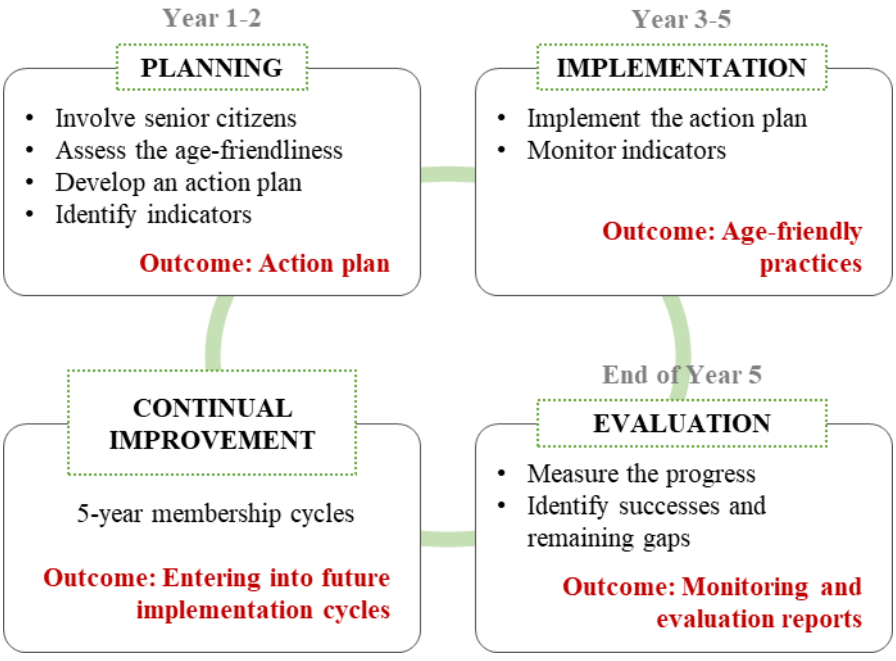


Figure 1-2 Five-Year Cycle of the *Global Network* (WHO, 2017)

1.1.2 Age-Friendly Communities (AFCs): Empowering Seniors in Daily Life

Since age brings senior citizens sensory along with other physical and psychological changes, they face more challenges in life. Meanwhile, changing future urban senior citizens' expectations to be active after retirement and their participation in the community will require an environment that offers senior citizens extensive and varied opportunities (Fitzgerald and Caro, 2014).

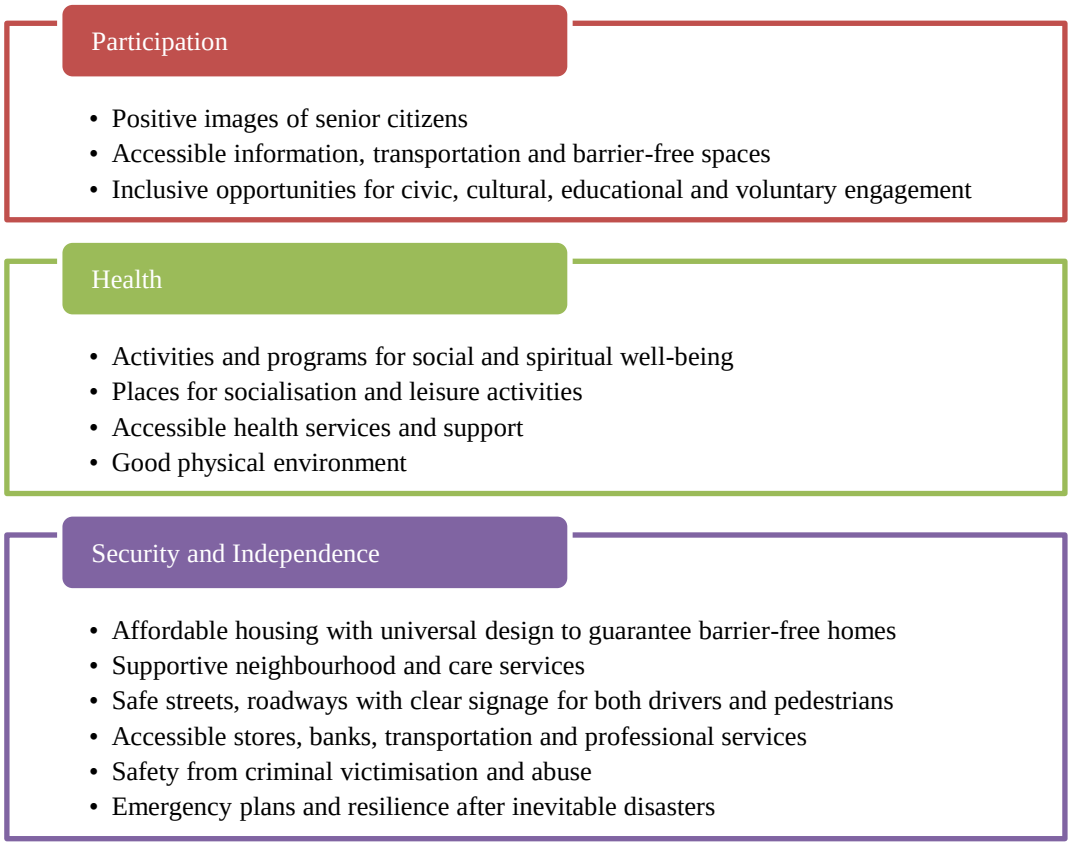


Figure 1-3 AFCs' Consideration of Seniors (WHO, 2019)

Senior citizens tend to spend much of their time in communities they live in after retirement. Considering the factors of participation, health, security and independence, AFCs are designed to support senior citizens in ageing actively and to empower them

in daily life (Figure 1-3). Living in AFCs, seniors' diversity can be recognised, their decisions can be respected, their inclusion can be promoted, and their contributions can be appreciated. Furthermore, ageing-related needs and preferences are likely to be anticipated and responded to flexibly in AFCs.

Most international models that have gradually been developed in countries such as Australia, Canada, the USA, the UK, and New Zealand, have been based on the WHO's guidelines. Although different terms are adopted when age-friendly initiatives are first promoted (for example, the term 'liveable community' is more common in the USA, whereas 'lifelong neighbourhood' is widely used in the UK when referring to building age-friendly environments for senior citizens), such models generally focus on how social and physical environments can empower seniors in their daily lives (Table 1-1).

Furthermore, based on the fact that all the provinces in Canada have initiated age-friendly processes and nearly 800 communities have launched age-friendly initiatives, researchers plan to capture how the key components of AFCs can foster positive health, social participation and health equity by carrying out quantitative and qualitative surveys in 3555 Canadian communities (Levasseur et al., 2017).

Table 1-1 Features of AFCs Identified by Predominant Models

(Bevan and Croucher, 2011; Government of South Australia, 2012; Stanton, 2014; Government of Canada, 2016; Super Seniors, 2018)

Model	**Age-Friendly Neighbourhood**	**Age-Friendly Community**	**Age-Friendly Community**	**Lifetime Neighbourhood**	**Livable Community**
Region	Australia	Canada	New Zealand	UK	USA
Organization	Government of South Australia	Government of Canada	Super Seniors, Ministry of Social Development	Local Government, Department for Communities	American Association of Retired Persons (AARP)
Physical Environment	Design and maintenance of public spaces, buildings	Pleasant, safe and accessible neighbourhoods; outdoor areas; and public buildings	Well-maintained public green spaces	Built and natural environments	Liveable places for all ages Fitness and fresh air Places to sit and wait
	Transportation	Accessible roads, walkways and transportation	Public transport and safe paths for pedestrians	Access	Safety road for pedestrians and drivers
	Housing	Affordable housing	Affordable housing options	Housing	Sidewalks and streetlights
	Communication and information	Clear and easy to find information	Clear, easy to read signage		A town centre and/or a community living room
Social Environment	Community support and health services	Available health, community support services	Closely located facilities	Services and amenities	
	Respect and social inclusion	Respectful relationship	Community activities for seniors' participation and decision-making	Social networks/well-being	
	Civic, social participation and employment	Opportunities for social participation		Supporting and empowering residents	

1.1.3 China's Age-Friendly Journey in Urban Settings

Ageing has raised questions regarding how prepared national, provincial, and local governments are to support the needs of such a heterogeneous population (Hartt and Biglieri, 2018). China's population is growing old at a faster rate than almost any other country: The effects of the 36 years of China's *One-Child Policy* (from 1980 to 2016), combined with dramatic improvements in health care, have contributed to increases in life expectancy and decreases in the birth rate of China.

In response to the WHO's *Global Age-Friendly Cities* programme, China carried out a national programme on a trial basis in 13 cities within six provinces in 2009. After two years, in November 2011, the city of Qiqihar became China's first member of the *Global Network*. Qiqihar's goal was to build a city where older people could be supported, enjoy medical care, contribute to society, engage in life-long learning and live happily. The *Qiqihar Committee on Ageing* is the major government department of the city involved in conducting age-friendly related actions (WHO, 2020). Hong Kong also began promoting AFC programmes in early 2009, and 18 districts have become members of the *Global Network*, with one of them already having finished the first five-year cycle and begun the second, while 14 of them have begun carrying out their strategies and action plans (Table 1-2).

Table 1-2 Hong Kong Districts' Membership in the *Global Network* (WHO, 2020)

District	Population (People over 60, %)	Time to Join the Network	Stage in Age-Friendly Journey
Kowloon City	7,413,100 (24.10%)	2019	Strategy and action plan
Sham Shui Po	405,869 (22.30%)	2018	Strategy and action plan
Eastern	555,034 (23.20%)	2018	Strategy and action plan
Tuen Mun	487,546 (16.03%)	2018	Strategy and action plan
Wong Tai Sin	425,253 (24.20%)	2018	Strategy and action plan
Yuen Long	578,529 (13.89%)	2018	Strategy and action plan
Yau Tsim Mong	342,970 (21.81%)	2018	Evaluation and entering cycle 2
Central and Western	248,600 (15.10%)	2018	Strategy and action plan
Islands	156,800 (15.00%)	2017	Strategy and action plan
Wan Chai	150,900 (24.00%)	2017	Strategy and action plan
North	315,600 (19.80%)	2017	Commitment letter
Tai Po	310,500 (20.19%)	2017	Strategy and action plan
Sha Tin	660,200 (13.97%)	2017	Strategy and action plan
Kwun Tong	639,900 (16.70%)	2017	Strategy and action plan
Southern	270,000 (15.20%)	2016	Strategy and action plan
Sai Kung	444,000 (8.90%)	2015	Baseline assessment
Tsuen Wan	304,637 (18.40%)	2015	Baseline assessment
Kwai Tsing	520,000 (20.00%)	2014	Strategy and action plan

Apart from such members of the *Global Network*, the *China National Committee on Ageing* (CNCA) proposed the 'liveable environment' concept and began pilot projects in several cities and communities as early as in 2009. The CNCA also suggested conducting work to create 'warm family' for senior citizens as an extension of the age-friendly concept. On the basis of the pilot projects, the 2012 version (implemented in 2013) of the *'Law of the People's Republic of China on Protection of the Rights and Interests of the Elderly'* included a new chapter entitled 'liveable environment' that made the construction of a liveable environment a legal

requirement. In addition, in 2016, the CNCA put forward guidelines that mainly focused on promoting an age-friendly environment. Milestones were set for developing diverse age-friendly cities and communities by the year 2025.

Although certain achievements have been made in urban settings since 2009, an AFC includes not only physical infrastructures but the social participation of senior citizens. Therefore, plans for building AFCs are still quite limited. For example, most actions taken focus only on ensuring accessible environments and providing barrier-free facilities at the community level. Such facilities are mainly designed for disabled persons rather than senior citizens. Thus, the current plans make senior citizens unwilling to utilise such facilities.

Transforming existing urban housing estates to AFCs in urban Chinese settings requires the efficient collaboration of many parties, including but not limited to the housing, health, long-term care, social protection, transport, labour, information and communication. Such projects require the active involvement of multiple participants, such as governments, service providers, civil societies, senior citizens and their organisations, families and friends. Efforts in addressing a variety of issues that arise from long construction periods must also be made considering the current conditions of urban settings, where China still has a long way to go.

1.2 Statement of the Research Gap

Numerous efforts have been made to construct AFCs in China by national, regional, and local organisations during the past few decades. The eight domains proposed by the WHO can provide a reference for evaluating whether a physical environment is sufficiently age-friendly and thus beneficial for seniors' health. In addition to the physical environment, the social environment is a significant part to guarantee the quality of seniors' retirement life, and key stakeholders of AFC projects must cooperate to achieve an inclusive environment for senior citizens.

Although in 2016, the CNCA put forward guidelines for promoting a liveable environment that presented basic principles, developing goals, major tasks and supporting measures, limited attention has been paid to key stakeholders' different concerns on critical success factors (CSFs) for AFC projects at the beginning. As no detailed guidelines have yet been proposed regarding key stakeholders' involvement and responsibilities, it is not clear whose interests should be given the highest priority when conflicts occur. In addition, the question of how to promote effective collaborations among key stakeholders also lacks sufficient consideration.

1.3 Aim and Objectives

Given the above discussion, this research aims to examine whether a multi-agent platform (MAP) on which key stakeholders' relationships and their concerns on the

CSFs are taken into consideration, can support the briefing stage of AFC projects in urban China. The specific objectives of this research include:

(1) To identify key stakeholders engaged in AFC projects and CSFs for AFC projects;

(2) To examine the relationships of key stakeholders according to their concerns on CSFs during the briefing stage of AFC projects;

(3) To design a MAP for the briefing stage of AFC projects to support consensus building among key stakeholders.

1.4 Research Questions

In relation to the three research objectives, several research questions are raised:

(1) Are key stakeholders engaged in AFC projects in urban China similar to other countries or regions throughout the world? How to categorise different CSFs for AFC projects?

(2) Do key stakeholders' concerns on CSFs differ during the briefing stage of AFC projects? If so, can they be categorised into different groups based on their different priorities?

(3) What factors can influence the consensus building among key stakeholders? Are there any strategies that can be helpful to tackle these influences?

1.5 Research Scope

This research will mainly focus on age-friendliness at the community-level, in the urban context of mainland China. From the view of social structure, communities can be divided into four categories that are most widely recognised by researchers, which are traditional housing block communities, tribal *danwei* communities, hybrid comprehensive communities and transfiguring marginal communities (Bray, 2006; Zhao, 2014). In this study, the term 'urban housing estates' is related to traditional housing block communities that are composed of residential and commercial buildings. To make the scale of 'urban housing estates' clear, from the view of urban planning and design, the 'five-min pedestrian-scale neighbourhood' in the latest *Standard for Urban Residential Area Planning and Design* (GB 50180-2018) introduced by the *Ministry of Housing and Urban-Rural Development of the People's Republic of China*, is also used to define 'urban housing estates' in this study. The 'five-min pedestrian-scale neighbourhood' means residential areas with 5,000 to 12,000 residents (approximately 1,500 to 4,000 households) whose daily needs can mostly be satisfied within five minutes' walking distance. The neighbourhood is equipped with serving facilities and is enclosed by urban streets.

Briefing, which is also known as 'architectural programming' in the USA, is the first step in the design process during which client requirements for a project are defined,

clarified, articulated, and major commitments of resources are made (Kelly and Duerk, 2002; Olatokun and Pathirage, 2015; Yu and Shen, 2015). The *Royal Institute of British Architects* (RIBA) organises the process of briefing, designing, delivering, maintaining, operating and using a building into eight stages (Figure 1-4). The first two stages, specifically, 'strategic definition' and 'preparation and briefing' are combined as the pre-design period of a construction project (RIBA, 2020).

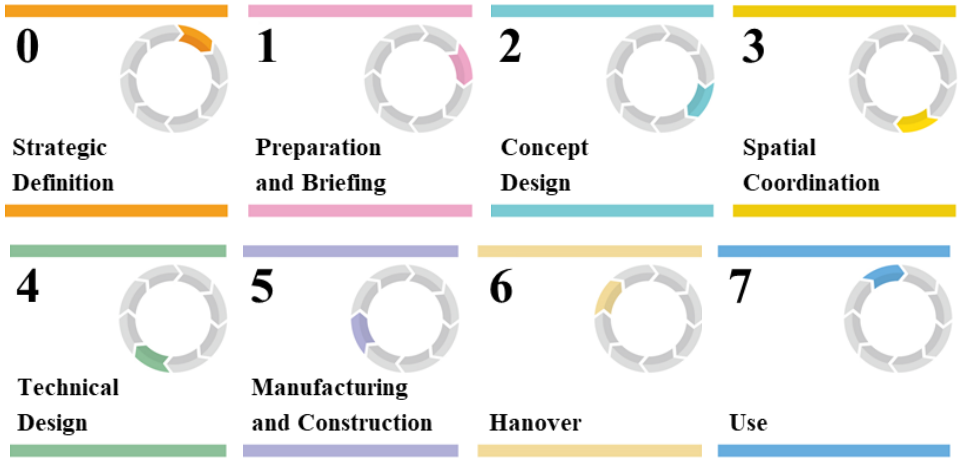


Figure 1-4 Eight Stages of the RIBA Plan of Work (RIBA, 2020)

The 'strategic definition' stage focuses on making the right strategic decisions, which involves considering the pros and cons, project risks and project budget; and carrying out site surveys and corresponding planning appraisals. The 'preparation and brief' stage involves developing an initial project brief, carrying out feasibility studies, undertaking a project risk assessment, and assembling the project team. The preparatory work of 'preparation and brief' stage enables the design process to begin.

The term ‘briefing’ in this study refers to RIBA’s pre-design period and focuses on exploring different stakeholders’ concerns and defining the responsibilities. All key stakeholders of AFC projects are suggested to be involved.

1.6 Research Design

This research will follow the process shown in Figure 1-5. The figure illustrates research objectives, corresponding methods and analytical tools, and expected research results.

The thesis contains seven chapters:

Chapter 1 is an introduction of the research, which includes the background, the statement of research gaps, aim and objectives, the scope and design of the research, and the significance and value of the study. The structure of the thesis is also introduced in this chapter.

Chapter 2 provides a scientometric review of studies on age-friendly cities and communities (AFCCs). The foundation and hot topics of AFCCs research are identified based on the keywords and document co-citation networks generated from 231 collected publications. Three major themes, specifically, characteristics of AFCCs, worldwide experiences in promoting AFCC projects, and measurement of

cities' and communities' age-friendliness, are summarised. Furthermore, a roadmap for AFCC research is developed.

Chapter 3 summarises how multi-agent systems (MASs) would be applied in the construction management area, with a focus on the project level. Apart from the discussion about the characteristics of applying MASs and the future research directions for the exploration of MASs in the construction management area, a framework for developing agent-based models is proposed, which is referred to when simulating key stakeholder relationships in this research.

Chapter 4 captures the research methods and analytical tools that are employed in the study and introduces under which circumstances such items would be used. The research methods include a literature review and document analysis, the Delphi method, the focus group discussion, and the case study. The analytical tools applied in this study are social network analysis and agent-based modelling techniques.

Chapter 5 first identifies key stakeholders' and their roles in AFC projects, CSFs for AFC projects and the importance of the briefing stage. Then, a two-mode social network is applied to identify the relationships of key stakeholders. Based on the results, key stakeholders concerns on CSFs, challenges of AFC projects in mainland China, and potential strategies to mitigate conflicts among key stakeholders that

caused by their different concerns on CSFs during the briefing stage of AFC projects are analysed.

Chapter 6 describes an agent-based simulation of how consensuses are built among key stakeholders, proposes strategies for AFC projects in urban China based on a real case, and validates the effectiveness of such strategies. A MAP is then designed for the briefing stage of AFC projects to assist in mitigating key stakeholders' conflicts.

Chapter 7 is the last chapter of the thesis. The research objectives are reviewed, and their fulfilment is examined. The key findings are summarised based on the studies conducted in the previous six chapters. Theoretical and practical contributions are concluded. Limitations and future directions are proposed.

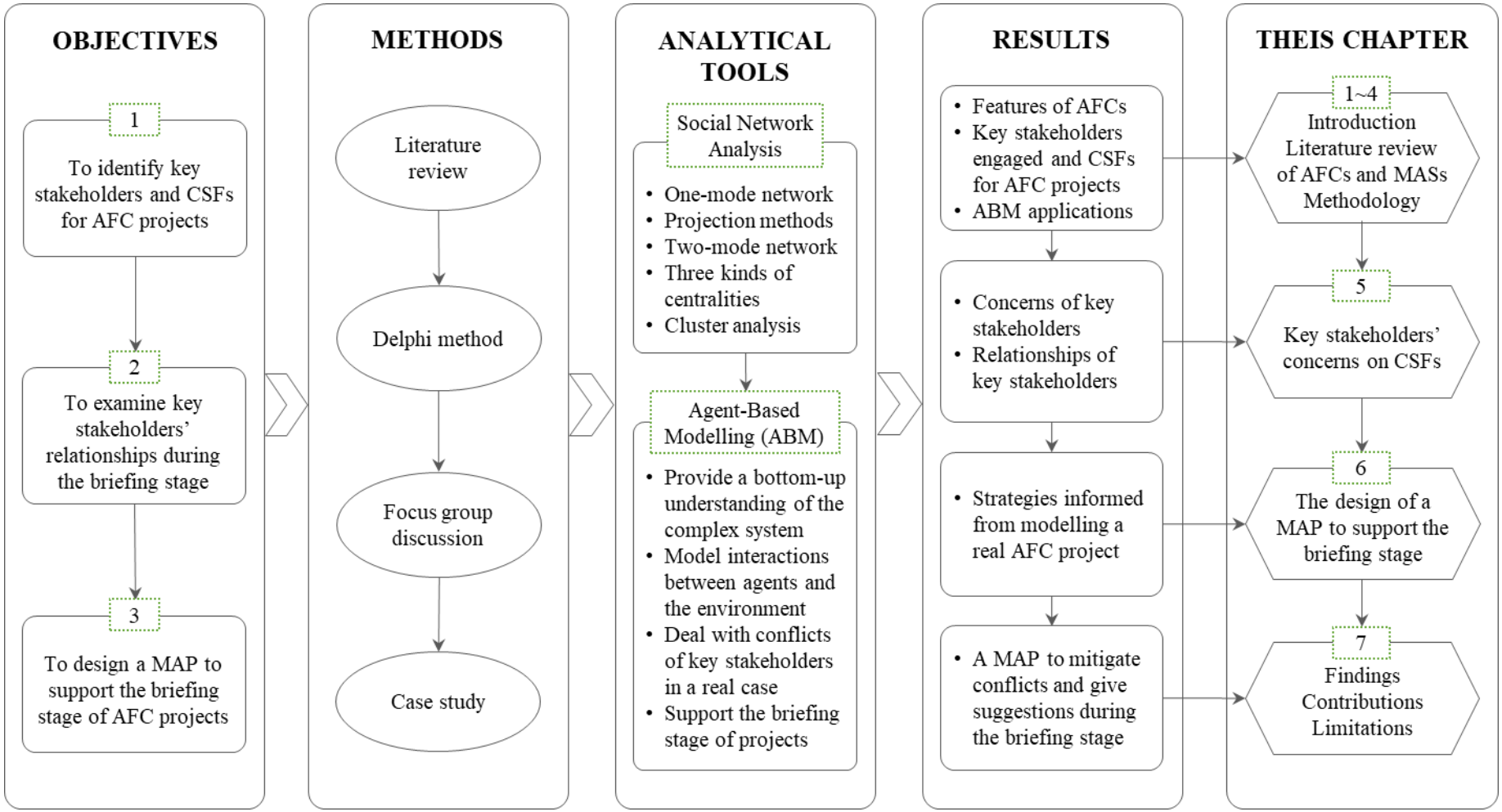


Figure 1-5 Research Framework

1.7 Significance and Value of Research

The movement towards AFCCs is growing nationally and internationally. Chinese citizens aged 60 years and older reached 241 million by the end of 2017, representing 17.3% of the total population, which was the first time when China witnessed an annual increase of more than 10 million senior citizens. This figure is projected to peak at 487 million, or approximately 35% of China's total population around 2050 (Xiang, 2018).

Active ageing is a lifelong process, and an AFC with an accessible, healthy and safe environment is not only beneficial to senior citizens, but to society as a whole. For example, barrier-free facilities and environments can enhance vulnerable people's mobility and independence, and a secure neighbourhood allows residents to venture outside and participate in social activities. In addition, community support and health services guarantee that residents of such facilities will experience less stress.

AFC projects require efforts of key stakeholders from many parties, such as housing, municipal planning, public health and non-governmental organisations (NGOs). It is not easy to convince each party to be enthusiastic immediately; therefore, strategic measures must be taken to most effectively engage key stakeholders. If the proposed MAP can be made into a reality, it will be more likely that key stakeholders' collaboration will be more efficient.

CHAPTER 2 A REVIEW OF STUDIES ON AGE-FRIENDLY CITIES AND COMMUNITIES[1]

2.1 Introduction

This chapter aims to provide a comprehensive review of the existing literature pertaining to age-friendly cities and communities (AFCCs). A total of 231 collected publications are analysed and visualised. Based on the keywords and document co-citation networks that are generated, the foundation, hot topics and critical areas of AFCC research are identified; future research directions are proposed; a roadmap for AFCC research is developed.

2.2 An Overview of AFCC Research

Web of Science (WoS) and Scopus are the most commonly used international databases in conducting the literature reviews (Ekanayake et al., 2019; Luo et al., 2019; Wuni et al., 2019). The search terms in the current study were ‘age-friendly’ or ‘elderly-friendly’ + ‘city’ or ‘community’. The ‘document type’ was limited ‘article’ and ‘review’, while the ‘language’ was limited to ‘English’ in the two databases. These settings were chosen to retrieve original and review articles on AFCCs.

[1] Parts of this chapter were published by *Ageing & Society* in the paper entitled ‘Emerging evolution trends of studies on age-friendly cities and communities: A scientometric review’.

Although the concept of an ‘age-friendly city’ was officially proposed by the WHO in 2007 and the *Global Network* was established in 2010, previous discussions have also contributed to the concept. Thus, the search for publications (executed on September 17, 2019) did not limit the publication year, and the results show that the beginning of AFCC research can be tracked to 2003. After the duplicate results from WoS and Scopus were merged, a cross-contrast was conducted. *InCites Journal Citation Reports 2019* was used to identify articles and reviews published in SCI-Expanded or SSCI journals. If a certain review or article was published in SCI-Expanded or SSCI journals, it was selected for further processing; otherwise, it was excluded. Thus, the author sought to ensure that the publications were retrieved from recognised journals.

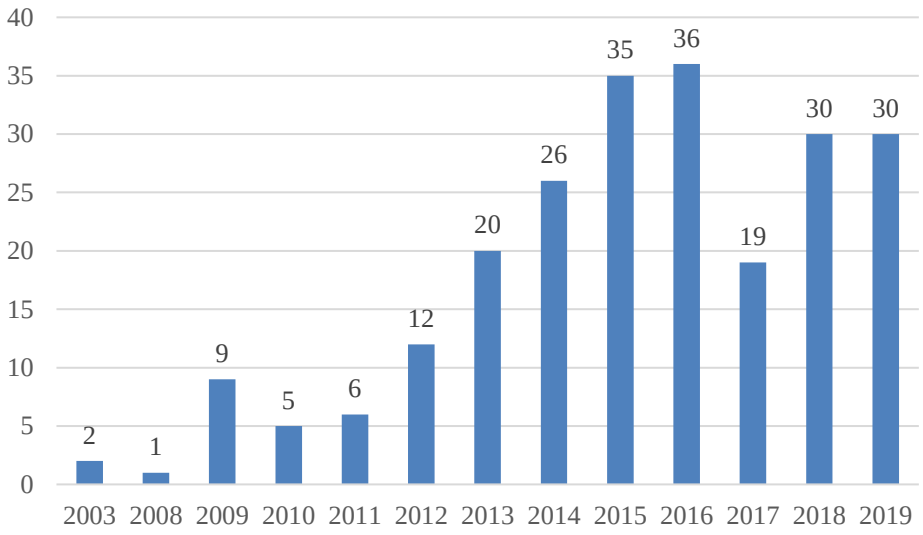


Figure 2-1 Distribution of Selected AFCC Publications by Year

After the data collection process, a total of 320 articles and reviews identified with duplicate results from WoS and Scopus were merged (as of October 2019). Based on

the aforementioned inclusion and exclusion criteria, 231 journal papers published in SCI-Expanded or SSCI journals related to AFCCs were included. Figure 2-1 illustrates the number of papers published in different years, and there was a sharp increase from 2011 to 2015. Table 2-1 summarises the distribution of the selected papers in the top 15 journals. Each included journal published no less than three relevant research papers. Most of the journals are related to gerontological and social studies, whereas some of them are related to environmental and health studies.

Table 2-1 Distribution of Selected AFCC Publications by Journal

Journal	Quantity	Percentage
Gerontologist	55	23.81%
Journal of Aging & Social Policy	17	7.36%
Ageing & Society	16	6.93%
Journal of Applied Gerontology	9	3.90%
International Journal of Environmental Research and Public Health	8	3.46%
Generations–Journal of the American Society on Aging	8	3.46%
Journal of Urban Health–Bulletin of the New York Academy of Medicine	7	3.03%
Canadian Journal on Aging–Revue Canadienne du Vieillissement	7	3.03%
Journal of Social Work Practice	6	2.60%
Journal of Gerontological Social Work	6	2.60%
Journal of Aging Studies	5	2.16%
Australasian Journal on Ageing	4	1.73%
Sustainability	3	1.30%
Journal of Aging and Health	3	1.30%

To complete the scientometric analysis process, each bibliographic record of the retrieved article was downloaded. A bibliographic record includes a series of data: author(s), title and abstract, keywords, and references cited by the article. Based on

the aforementioned information, a co-citation analysis was conducted, which provided a unique means of illustrating the structure and dynamics of the scientific paradigm. By showing the relationships of the retrieved papers and the corresponding reference records, the co-citation analysis provides an opportunity to measure the proximity of the publications.

Three analytic methods in *CiteSpace* were applied. First, a keyword co-occurrence network was generated to determine the contents of the AFCC publications, and the analysis result is considered to represent the foundation of AFCC research. Second, a document co-citation network was generated and divided into clusters to reflect the various domains of AFCC research. Specific publications clusters revealed numerous similarities with one another. The result is considered to indicate the hot topics developed in accordance with the WHO's age-friendly concept. Last, frequently cited publications and references with citation bursts were identified, which describe the main concerns of scholars and define the critical areas of AFCC research.

2.2.1 The Foundation of AFCC Research

Keywords are generally selected by authors to refine the content of publications. Therefore, keyword analysis was used to facilitate the identification of researchers' key concerns with regard to AFCCs. Based on the frequencies of AFCC-related keywords, the co-occurrence network was generated using *CiteSpace*. Figure 2-2 and

Figure 2-3 provide visual descriptions. A standardised process was conducted to classify the original terms generated by *CiteSpace* with similar meanings. For example, ‘age-friendly community’, ‘age friendly community’, ‘age-friendly city’ or ‘age friendly city’ were grouped as ‘AFCCs’. After standardisation, the top 25 terms mentioned by scholars for no less than four times were determined, with a total frequency of 376 time. Table 2-2 lists these items.

Figure 2-2 and Table 2-2 reveals that AFCC has the highest frequency, with 70 occurrences. If the frequencies of ‘age-friendly / ageing-friendly / elder-friendly’, ‘age-friendliness’, ‘city’, ‘community / urban community’ and ‘community development’ are also added, then the total frequency of AFCC is 166. This finding is typical given that researchers tend to choose the main topic as one of the keywords, and such combinations of terms are also part of the criteria when selecting papers.

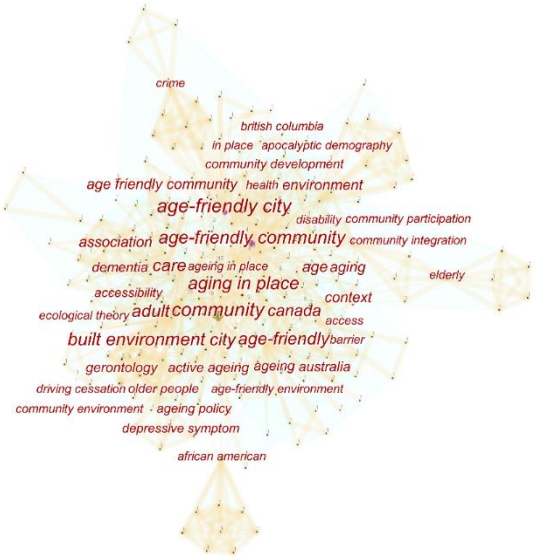


Figure 2-2 Keyword Co-Occurrence Network

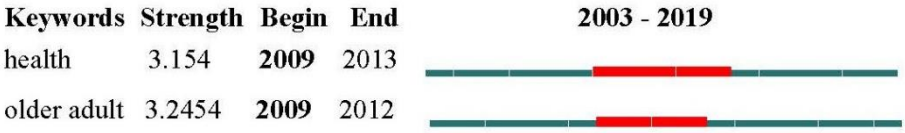


Figure 2-3 Top 2 Keywords with the Strongest Citation Bursts

Table 2-2 Top 25 Items with their Frequencies

Frequency	Keyword
70	AFCC (Age-friendly community / city / municipality, Ageing-friendly community, Elder-friendly community)
40	Community / urban community
38	Ageing in place / city / community / neighbourhood
32	Older adult / people, Ageing adult, Community-dwelling older people, Aged, Elderly, Elder
23	Age-friendly, Aging-friendly, Elder-friendly
19	Ageing, growing old
19	Built / community / physical environment
19	City
16	Care
11	Canada
11	Health, Healthy ageing, Healthy city
8	Active ageing
8	Age
8	Association
7	Age-friendliness
7	Community development
6	Environment
5	Australia, Canberra
5	China, Chinese, Beijing
4	Accessibility
4	Ageism
4	Civic engagement / participation
4	Dementia
4	Disability
4	Physical activity / exercise, Leisure-time physical activity

The United Nations proclaimed 1999 as *The Year of Older Persons*, at which time the 'age-friendly' concept was initiated (Rosochacka-Gmitrzak, 2016). According to the *Policy Framework on Active Ageing* introduced in 2002, the 'Age-Friendly City' concept has gained attention worldwide since the WHO launched the *Global Age-Friendly Cities* project in 2007. The establishment of the *Global Network* in 2010 indicated that not only cities but other areas could also be age-friendly. The main concept behind 'age-friendliness' is the recognition of senior citizens' ability to contribute to society through active participation and neighbourhood engagement, as long as their health conditions allow (Chan and Cao, 2015).

After AFCC-related items, 'ageing in place' ranks second in terms of frequency. In particular, this term, including similar phases, such as 'ageing in neighbourhood / community / city', is mentioned 38 times as a keyword. Davey et al. (2004) defines 'ageing in place' as 'remaining living in the community with some level of independence, rather than in residential care'. In numerous countries, senior citizens' sense of belongingness increases the popularity of 'ageing in place'. Therefore, given the extant social and economic issues, a wide consensus has been reached by governments and international associations regarding setting 'ageing in place' as a policy goal (Pynoos et al., 2008; Sixsmith and Sixsmith, 2008; Lui et al., 2009; Hillcoat-NallÉTamby and Ogg, 2013; OECD, 2015; Scharlach, 2016; Xiang et al.,

2020). Ensuring the level of senior citizens' independence by providing them with essential facilities, including hazard-free streets and buildings, accessible stores, banks and professional services, is part of the AFCC endeavour. Therefore, promoting AFCCs could be beneficial toward achieving the goal of 'ageing in place'.

The third-largest research item is related to 'older adult', and the total frequency of all similar expressions, such as 'older people', 'ageing adult', and 'community-dwelling older people', is 32 times. Older people can be identified as the most important 'end users' of AFCCs, and their satisfaction with the cities and communities in which they live is relevant in the promotion of AFCCs. This notion can explain why 'older adult' has become one of the top two keywords with the strongest citation bursts (Figure 2-3). In particular, the WHO focuses on caring about what seniors experience as age-friendly in their daily lives in their community and on involving them as partners from the beginning to the end of a project. This notion can also explain why 'civic engagement' and 'civic participation' are selected by authors as keywords.

The keywords related to 'environment', including 'built environment', 'community environment', 'physical environment' and 'accessibility' appear with a total frequency of 29 times. Over the past few decades, the rising significance of environmental gerontology has fuelled discussions on the dynamic relationships between senior citizens' quality of life and the social and physical environments where they live

(Phillipson, 2011; Wahl et al., 2012). Thus, issues related to ‘ageing’, ‘growing old’ ‘age’, and ‘ageism’ have received growing research attention in the fields of gerontology, social science and the built environment. Given the long periods that senior citizens may spend at home and in their communities, together with the fact that walking is seniors’ most common form of physical activity, they are likely to be sensitive to changes in the built environment (Nagel et al., 2008; Peace et al., 2011; Kerr et al., 2012) whilst the accessibility of the environment affects their choices of physical activities. Age-friendly efforts under such circumstances may shift from merely focusing on individual outcomes to the environment where seniors live (Jeste et al., 2016). Related approaches, such as promoting supportive neighbourhoods and developing connections with families and communities, have emerged as overarching themes that might help address seniors’ social and physical issues (Buffel et al., 2012; Glicksman et al., 2014; Biggs and Carr, 2015; Lowen et al., 2015; Chan et al., 2016).

The results further indicate that health-related keywords such as ‘health’, ‘healthy ageing’ and ‘healthy city’ are selected 11 times. Healthy ageing is defined as ‘the process of developing and maintaining the functional ability that enables well-being in older age’. The term is based on the previous ‘active ageing’ framework and was the focus of the WHO’s work on ageing from 2005 to 2010. The top two keywords with strong citation bursts contain ‘health’ as an item from 2009 to 2013 (Figure 2-3),

which is also consistent with the trend. The AFCC practice records in the global database indicate that the health sector is involved in 61 out of 208 practices, which accounts for 29.3 per cent. The summary of AFCC practices by sector also illustrates that health and social protection sectors are the most frequently leading sectors for such practices (Figure 2-4).

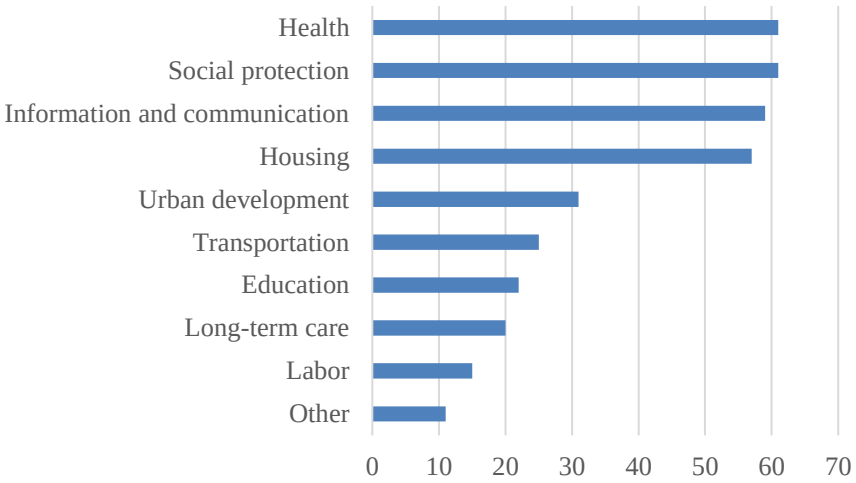


Figure 2-4 Breakdown of AFCC Practices by Sector

Given that the accumulation of improvements in modern medical levels enable people to maintain a healthy physical condition, senior citizens will be healthier, wealthier, better educated and more willing to acquire information and participate in social life near places where they live (Everingham et al., 2009; Lehning et al., 2009; Beard and Bloom, 2015; Chan and Cao, 2015; Staube et al., 2016). The 'healthy ageing' framework demonstrates that engaging in physical activity is considered to be a key behaviour and generates multiple benefits in old age, which can explain why 'physical

activity', 'physical exercise' and 'leisure-time physical activity' are selected by authors as keywords. In addition, care system, especially long-term care systems, are considered to ensure that people with limited *Activities of Daily Living* (ADL) levels maintain a baseline of functional ability with the presence of physical disability or cognitive disorders. Thus, 'care', 'dementia', and 'disability' are also selected.

Certain country-specific keywords such as 'Canada' (frequency = 11), 'Australia' and 'Canberra' (total frequency = 5), 'China', 'Chinese' and 'Beijing' (total frequency = 5), also appear several times. Therefore, studies related to AFCCs under certain backgrounds have attracted more attention from these three countries compared with others. The keyword 'association' illustrates the efforts contributed by international groups apart from the WHO, such as the AARP in the USA, *Super Seniors* in New Zealand and the *Department for Communities and Local Government* in the UK.

2.2.2 Hot Topics of AFCC Research

The document co-citation network generated in *CiteSpace* can be viewed by clusters with noun-phases as the labels. Each label of the automatically identified cluster is retrieved from publication titles, keywords and abstracts, which provides latent semantic themes within the textual data (Luo et al., 2019). Three algorithms, specifically, the *latent semantic index* (LSI), the *log likelihood ratio* (LLR), and the *mutual information* (MI) were applied to identify the most significant clusters and

related terms of AFCCs. In particular, the LSI test was used to determine the most salient term of a cluster, whilst the rest tended to represent the unique aspects of the clusters (Chen et al., 2010). Figure 2-5 and Table 2-3 illustrate the six labelled clusters along with their statistical importance generated by *CiteSpace* via an LLR test. The size of each cluster was determined by the number of publications, including research papers, book chapters and reports.

Figure 2-5 Cluster View of AFCC Research

Table 2-3 Top 6 Clusters and Related Terms

Cluster-ID	Size	Silhouette	Mean (Cited Year)	LLR
0	33	0.686	2014	Urban ageing
1	32	0.749	2010	Rural communities
2	25	0.599	2014	Age-friendly community planning
3	24	0.704	2011	Ideal neighbourhood
4	16	0.868	2008	Competing framework
5	8	0.846	2010	Purpose-built retirement communities

(1) Urban Ageing and Planning for AFCCs

From the clusters created by *CiteSpac*e in Figure 2-5 and the description in Table 2-3, the largest and most important cluster is labelled as '#0 Urban ageing', which includes 33 publications. The publications that comprise this cluster tend to reveal researchers' concerns regarding whether the healthy cities and communities that foster active ageing can also be identified as AFCCs based on the types of pressure that affect the urban environment and on the process of how AFCC frameworks promote changes in urban areas (Scharlach, 2009; Boudiny, 2013; Kendig and Phillipson, 2014; Jackisch et al., 2015). Some of the topics discussed above also appear in the third-largest cluster that is labelled as '#2 Age-friendly community planning'. For example, Scharlach (2017) examined the environmental pathways for promoting active ageing and developed the constructive ageing concept to reflect the adaptation between individuals and environments. The implementation of the consultative mechanism can involve senior citizens in the decision-making process of urban policies or age-friendly initiatives, and AFCC policies' successes depend heavily on the evolution of powerful urban networks (Keyes et al., 2014; Buffel and Phillipson, 2016; Rémillard-Boilard et al., 2017; Buffel and Phillipson, 2018).

Consistent with the appearance of country-specific keywords, several publications in Cluster #0 have discussed the lessons learned from experiences of building AFCCs,

which is again the main concern of Cluster #2. Within the Western context, Canadian experiences from Quebec cases illustrated the importance of collaborative partnerships for the success of implementation (Garon et al., 2014). The major barriers for communities in implementing age-friendly projects were highlighted in the *Manitoba Initiative* (Menec et al., 2014). Through evidence-based, iterative consultation research, Orpana et al. (2016) listed 39 indicators to support AFCC evaluation activities. Experiences from the UK include Manchester's progress in tackling health and other inequalities in the deprived urban areas (McGarry and Morris, 2011) and the ways in which senior citizens living in low-income neighbourhoods of Manchester can be recruited and trained as co-researchers (Buffel, 2018). Neal et al. (2014) indicated efforts in building relationships between universities and local government agencies in Portland and developed a guidebook for community executives to evaluate the communities' progress to become age-friendly (Neal and Wernher, 2014). In the USA, surveys conducted in the Great Bay Area showed that the local and regional government provided a number of age-friendly features, particularly alternative forms of mobility and features to strengthen the accessibility of public transit for seniors (Lehning, 2014). Studies conducted in Detroit linked environmental features with seniors' self-rated health and compared the potential influence of age-friendly characteristics between low-income and

high-income seniors' expectations of ageing in place (Lehning et al., 2014; 2015). Experiences from the Asia-Pacific include Australia's unique approaches to incorporating the WHO's age-friendly thinking into the policy initiatives of Melbourne, Sydney and Canberra (Kendig et al., 2014). Korea's adoption of the WHO's AFCC indicators within the 'Person-Environment Fit' perspective demonstrated that the age-friendly environment would be both beneficial and detrimental to senior citizens' well-being (Park and Lee, 2017). Such studies included a Japanese investigation on the constraints preventing seniors' interactions with society using the results from a 'Questionnaire towards an age-friendly city' conducted by Akita City (Kadoya, 2013). Also included was an analysis of a nationally representative survey within the WHO's framework in China, which identified missing environmental aspects in mainland regions (Wang et al., 2017). And a promotion of Hong Kong as an age-friendly city via the local charity's contributions (CUHK Jockey Club Institute of Ageing, 2017).

During the promotion of AFCCs, the relationship between the built environment and social inclusion and isolation issues has drawn researchers' attention; thus, several publications from Cluster #3 labelled as 'Ideal neighbourhood' also show concerns regarding this topic. For example, Cramm et al. (2013) discussed how cities and communities could be retrofitted such that senior citizens' physical and social needs

can be satisfied. Gonyea and Hudson (2015) proposed a framework that illustrated three continuum lines, specifically, population inclusion, environment inclusion, and sector inclusion, to enhance the understanding of AFCCs. Beyond the economic effects of neighbourhood changes (Freedman et al., 2008), the quality and quantity of people's social relationships and connections link senior citizens' mental health, mobility and mortality (Phillipson, 2007; Holt-Lunstad et al., 2010; Lehning et al., 2012; Nicholson, 2012) and affect soon-to-be-retired adults' life satisfaction and expectations (Emlet and Moceri, 2012). Therefore, social spaces in AFCCs play an important role in developing social links, increasing visibility and improving seniors' feelings of inclusion (Burns et al., 2012). Quantitative data provide evidence of people's mortality, which is affected by social isolation (Holt-Lunstad et al., 2015). Although there is limited convincing evidence for the assumption that senior citizens' health and functioning are primarily influenced by the built environment and hypothesis-driven studies are still needed, strong links exist between seniors' mobility and the physical environment where they live (Yen et al., 2009; Rosso et al., 2011; Cerin et al., 2017). For example, transportation disadvantages may lead to the social isolation of seniors, particularly older migrants who live in deprived urban areas (Mezuk and Rebok, 2008; Buffel et al., 2013). Access to care facilities, green spaces, social support, and community engagement were identified as having associations

with improved self-rated health, whereas neighbourhood problems often resulted in poorer self-rated health (Michael et al., 2006; Arrif and Rioux, 2011; Annear et al., 2014; Kim and Han, 2014; Lehning et al., 2014; Choi and DiNitto, 2016).

(2) Age-friendly Initiatives in Rural Communities

The second-largest cluster is labelled as '#1 Rural communities' and related discussions begin with the emergence of Canada's age-friendly rural and remote community idea building based on the AFCC work and the active ageing model (Healthy Aging and Wellness Working Group, 2007). Age-friendly studies in rural Canada can be summarised based on two lenses, specifically, the marginalisation lens and ageing-well lens. The former lens highlights rural seniors who suffer from health problems, whereas the latter focuses on seniors' contributions to families and communities (Keating et al., 2011). Case studies were mainly conducted by Canadian researchers to examine whether the differences between community characteristics, for example, population size and relative affluence, affect communities' age-friendliness, people's life satisfaction and self-perceived health (Lavergne and Kephart, 2012; Menec and Nowicki, 2014; Menec, Hutton, et al., 2015; Spina and Menec, 2015); Whether social care patterns and the negotiation of responsibilities in work and welfare arrangements were different in the remote and resource-dependent communities (Hanlon et al., 2007); And how voluntarism may be transformed as a

response to the challenges and opportunities of population ageing in rural communities (Joseph and Skinner, 2012). Interviews with stakeholders from local government, social care, health and community organisations in two rural communities in Australia were carried out by Winterton (2016), which raised questions regarding who should take the responsibility of implementing age-friendly initiatives. Focus group discussions with community stakeholders from Ireland and Northern Ireland have examined informal practices, particularly how private, voluntary, family and friend systems help to address social isolation issues in the rural communities (Walsh et al., 2014). Burholt and Dobbs (2012) conducted a review regarding social publications from 1999 to 2010 and determined the shortfalls of rural ageing studies in the European context. Given that most studies were dominated by the biomedical perspective, research at the macrolevel, including policies, and at the meso-level, including social networks and communities as well as the interplay between these two levels, should be promoted to improve the development of the ageing environment in rural areas.

Age-friendly initiatives in rural areas face more serious challenges than those in urban areas because of high-risk factors, including the inequitable distribution of healthcare resources, mobility constraints and other social and economic disadvantages (Hanlon and Halseth, 2005; Wilson et al., 2009; Ryser and Halseth, 2012). Therefore, the

age-friendly concept should incorporate place, people and time by taking into consideration the changes occurring to people and communities (Keating et al., 2013). Such issues were also discussed in Cluster #3. Although the effect of urbanisation increases the number of people moving to urban areas, numerous older adults still live in rural areas worldwide. Therefore, AFCC research should be conducted, and policy approaches should be promoted to address ageing-related issues in rural areas (Dandy and Bollman, 2008; Keating, 2008).

(3) Multiple Models for Creating Ideal Neighbourhoods

Apart from the aforementioned studies, clusters with the label of '#3 Ideal neighbourhood', '#4 Competing framework' and '#5 Purpose-built retirement communities' comprise broad topics, such as the characteristics in urban and rural areas that can improve communities to cater to the growing needs of old individuals and several planning concepts in response to the ageing society. For example, Lynot et al. (2009) proposed the *Complete Streets* initiatives in the USA, which aimed to change the streets designed mainly for motorists such that people's travel options could be improved regardless of age and ability. Gardner (2011) used a friendly visiting methodology to collect data over an eight-month period and highlighted natural neighbourhood networks as a new informal social network type that is important to seniors' well-being and quality of life. Buffel and Phillipson (2011)

interviewed senior migrants from minority ethnic groups and reviewed the creation of ideas related to 'home', the pressures they experienced and the meaning of transnational ties. Bernard et al. (2012) conducted a case study to examine retirement communities in the UK and to determine whether such communities help promote people's lifestyle aspirations. Van Dijk et al. (2015) applied Q-methodology, which combines qualitative and quantitative approaches for the exploration of viewpoints, to discuss and compare frail and non-frail senior citizens' perceptions on the neighbourhood characteristics that affect their decisions on ageing in place. In addition, Cluster #4 includes discussions on neighbourhood elements, physical activities and senior citizens' health. Among the various types of activities, walking is particularly recommended as a way to improve and maintain senior citizens' health (Berke et al., 2007; Nelson et al., 2007; Satariano et al., 2010).

2.3 Critical Areas of AFCC Research

Joint citations by subsequent publications indicate that document co-citation network analysis serves as a method to evaluate the critical research areas and the important publications (Ekanayake et al., 2019; Luo et al., 2019). Figure 2-6 illustrates the document co-citation network generated by *CiteSpace*, which includes 454 nodes and 1,410 links. Each node in the network represents a cited reference, whilst the connecting links between nodes indicate the relationships.

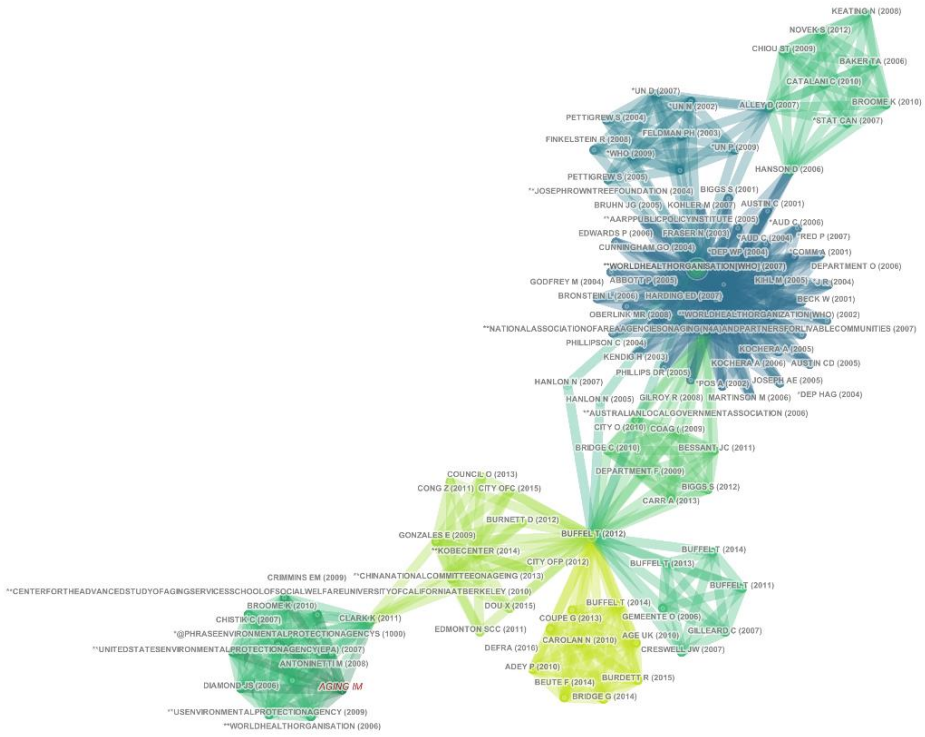


Figure 2-6 Document Co-Citation Network

Bibliographic records are imported into *CiteSpace* to complete the scientometric analysis process, and the co-citation network subsequently detects frequently cited publications according to the reference lists of the retrieved articles. The top 15 publications cited no less than ten times (Table 2-4) and the top 19 references with strong citation bursts (Table 2-5) contain a variety of items, including reports from the WHO, book chapters and journal papers. Table 2-4 and Table 2-5 reveal that seven items are generated as critical publications and references with strong citation bursts. Among the 19 references with strong citation bursts, ten of the bursts began after 2016, meaning that researchers' attention to AFCCs has increased within the last four years. Citation bursts during a period indicate that researchers pay special attention to

the contributions of the cited works. The cited frequency calculated by *CiteSpace* is slightly different from that calculated by WoS or *Google Scholar* since the strategy of retrieving papers ensures meaningful citations in the area of AFCCs. Thus, papers cited by studies in other areas are excluded.

Table 2-4 Top 15 Publications on AFCC Research

Frequency	Author	Title	Year	Source
48	WHO	* Global age-friendly cities: A guide	2007	WHO Library
39	Menec et al.	Conceptualizing age-friendly communities	2011	Canadian Journal on Aging
38	Lui et al.	* What makes a community age-friendly: A review of international literature	2009	Australasian Journal on Ageing
32	Buffel et al.	Ageing in urban environments: Developing 'age-friendly' cities	2012	Critical Social Policy
25	Plouffe and Kalache	Towards global age-friendly cities: Determining urban features that promote active aging	2010	Journal of Urban Health
24	Scharlachand Lehning	* Ageing-friendly communities and social inclusion in the United States of America	2013	Ageing & Society
18	Wiles et al.	The meaning of "aging in place" to older people	2012	Gerontologist
16	Alley	* Creating elder-friendly communities	2007	Journal of Gerontological Social Work
15	Fitzgerald and Caro	* An overview of age-friendly cities and communities around the world	2014	Journal of Aging & Social Policy
15	Plouffe and Kalache	Making communities age friendly: State and municipal initiatives in Canada and other countries	2011	Gaceta Sanitaria
14	Buffel et al.	Developing age-friendly cities: Case studies from Brussels and Manchester and implications for policy and practice	2014	Journal of Aging & Social Policy

(Continued)

Frequency	Author	Title	Year	Source
14	Scharlach	Creating aging-friendly communities in the United States	2012	Ageing International
11	Novek and Menec	Older adults' perceptions of age-friendly communities in Canada: A photovoice study	2014	Ageing & Society
10	Menec et al.	* How 'age-friendly' are rural communities and what community characteristics are related to age-friendliness? The case of rural Manitoba, Canada	2015	Ageing & Society
10	Greenfield et al.	* Age-friendly community initiatives: Conceptual issues and key questions	2015	Gerontologist

* The publication also has strong citation burst.

Table 2-5 Top 19 References with Strong Citation Bursts

References	Year	Strength	Begin	End	2003-2019
Assessing a community's elder friendliness: A case example of The AdvantAge Initiative	2006	1.7656	2009	2014	
Global age-friendly cities: A Guide	2007	13.6899	2009	2015	
Creating elder-friendly communities	2007	4.3714	2010	2015	
What makes a community age-friendly: A review of international literature	2009	3.5499	2011	2014	
Developing age-friendly communities: New approaches to growing old in urban environments	2011	2.8284	2013	2014	
Ageing and urbanization: Can cities be designed to foster active ageing?	2010	1.9555	2014	2015	
Conceptualizing age-friendly community characteristics in a sample of urban elders: An exploratory factor analysis	2013	1.4843	2015	2016	
Changing practice and policy to move to scale: A framework for age-friendly communities across the United States	2014	1.4843	2015	2016	
A tale of two community initiatives for promoting aging in place: Similarities and differences in the national implementation of NORC programs and villages	2013	1.4843	2015	2016	
Measuring the age-friendliness of cities: A guide to using core indicators	2015	1.513	2016	2019	
Moving beyond 'ageing in place': Older people's dislikes about their home and neighbourhood environments as a motive for wishing to move	2014	1.4505	2017	2019	
How 'age-friendly' are rural communities and what community characteristics are related to age-friendliness? The case of rural Manitoba, Canada	2015	1.4568	2017	2019	
Ageing-friendly communities and social inclusion in the United States of America	2013	1.7737	2017	2019	
World report on ageing and health	2015	1.9985	2017	2019	

(Continued)

References	Year	Strength	Begin	End	2003-2019
Age-friendly community initiatives: Conceptual issues and key questions	2015	2.2545	2017	2019	
Review of assessment tools for baseline and follow-up measurement of age-friendliness	2015	1.4505	2017	2019	
An overview of age-friendly cities and communities around the world	2014	4.3495	2017	2019	
Age-friendly environments and self-rated health: An exploration of Detroit elders	2014	1.8167	2017	2019	
Assessing communities' age-friendliness: How congruent are subjective versus objective assessments?	2016	1.4505	2017	2019	

2.3.1 Characteristics of AFCCs

Prior to the introduction of the AFCC concept, researchers began to discuss the process of how elderly-friendly community models, such as the *AdvantAge Initiative*, could be used to identify assets and areas for improvement (Hanson and Emlet, 2006). After the WHO's model was introduced in 2007, Lui et al. (2009) compared the key features of AFCCs identified by various models and described the AFCC discourse in two dimensions, specifically, the environmental dimension and the governance dimension. Plouffe and Kalache (2010) discovered that in developed cities, the listing of age-friendly features tended to be long and characteristics such as physical accessibility, proximity, security, affordability and inclusiveness were considered important in all locations. This finding was also consistent with a previous Delphi study conducted by Alley et al. (2007). Fitzgerald and Caro (2014) further clarified age-friendly features as precondition elements (population density, climate and weather, topographic features, social and civic organisation, health and social services) that should be settled if communities plan to pursue meaningful age-friendly initiatives, core features (housing, mobility, outdoor spaces and buildings, senior citizens participation) and secondary features (age-friendly business) that might contribute later to AFCCs.

Building upon the WHO's framework, several researchers have applied other theories

to define AFCCs. For instance, Menec et al. (2011) borrowed ecological theory from biology, focused on five principles derived from the literature and elucidated an ecological conceptualisation of AFCCs. The borrowed theory also guided Novek and Menec (2014) when they designed and completed the analysis process of their research following their view that senior citizens are essential within the community and the greater policy environment. Buffel et al. (2012) provided a perspective with regard to the shift in focus of AFCCs from ‘What is an ideal city for older people?’ to ‘How age-friendly are cities?’ Wiles et al. (2012) conducted focus group discussions and interviews with senior citizens regarding the meaning of ageing in place and determined that this concept referred to a sense of attachment and feelings of security and familiarity. Greenfield et al. (2015) found that the definition of AFCCs shared criteria with ‘who’, ‘where’, ‘what’, ‘how’ and ‘why’ dimensions.

2.3.2 Experiences in Promoting AFCC Projects

The lessons learned from experiences in promoting AFCC projects in various areas, particularly in Western countries, represent another critical research area. For example, Canadian experiences indicated three activity axes, specifically, strategic engagements, policy actions, and the knowledge development and exchange of federal, provincial and municipal government (Plouffe and Kalache, 2011). Menec, Bell, et al. (2015) claimed that existing partnerships and easy access to local leaders are strengths for

promoting AFCCs in remote communities based on a study conducted in Manitoba. The USA cases reflected the problem of limited political authority or economic resources and urged for creative destruction, such as challenging entrenched and stagnant bureaucracies, obsolete programmes and acknowledged efforts that were made through AFCC initiatives to promote social inclusion among senior citizens (Scharlach, 2012; Scharlach and Lehning, 2013; Ball and Lawler, 2014).

Researchers also investigated the leaders of other community-based models for ageing in place, such as *Villages and Naturally Occurring Retirement Community Supportive Service Programs* in the USA, which discussed the models' inclusivity, sustainability expansion and effectiveness and the process of benefiting other age-friendly initiatives (Greenfield et al., 2013). With regard to European cases, Buffel et al. (2014) compared Brussels and Manchester and indicated the importance of multiple stakeholder collaborations and the involvement of senior citizens and proposed barriers of ageist attitudes, economic and political difficulties and potential limitations in relation to the 'age-friendliness' concept.

2.3.3 Measurement of Age-Friendliness in Cities and Communities

Another notable research area relates to the measurement of age-friendliness in cities and communities and the mechanism of how age-friendliness is related to senior citizens' health. For example, apart from engaging seniors by improving the

walkability and accessibility of facilities in cities and communities, Beard and Petitot (2010) proposed strategies such as reducing crime and promoting urban safety, improving housing design and strengthening neighbourhood resources as approaches for cities to foster active ageing. Smith et al. (2013) applied an exploratory factor analysis method to an urban older Americans' sample including 1,376 participants and identified access to business, leisure and healthcare, social interaction, neighbourhood problems, social support and community engagement as important AFCC factors that are related to demographic and health features. Lehning et al. (2014) acknowledged a positive association between community engagement and self-rated health but claimed neither social interaction nor access to business and leisure factors as having a significant influence on self-rated health based on their target sample in Detroit.

With regard to the assessment of age-friendliness in cities and communities, the WHO introduced a guide for measuring age-friendly cities in 2015, and researchers conducted studies to discuss the assessment tools and processes. For example, Dellamora et al. (2015) identified 25 assessment tools through literature reviews and personal communications. The *Community Assessment Survey for Older Adults* was claimed to be the most comprehensive instrument with copyright protection, and it was applied repeatedly in 12 different communities in the USA. Menec et al. (2016) compared subjective assessments by residents in communities and objective

assessments by municipal officials and recognised that the municipal assessment could over-estimate a community's age-friendliness based on the ratings provided by community-dwelling residents.

2.4 A Roadmap for AFCC Research

The results analysed above reflect that current AFCC research can be summarised into three major themes: characteristics of AFCCs, experiences in promoting AFCC projects worldwide and measurement of cities' and communities' age-friendliness. Taking a house as a means of illustrating the AFCC research roadmap, its foundation would be formed by researchers' highly selected keywords, its pillars and windows would be the hot topics generated by the cluster view of the document co-citation network, its beams would be the summarised critical research areas, and its roof would be future research directions (Figure 2-7).

The concept and features of AFCCs should primarily be understood as promoting related initiatives. Apart from the age-friendly features that were included in the WHO's guidelines, community history and identity, ageing in rural and remote communities and environmental conditions were identified as key contextual factors that influence seniors' experiences within community environments. Intergenerational neighbourhoods and neighbourhood trust have been described as supportive factors (Biggs and Carr, 2015; Tiraphat et al., 2017). Furthermore, whether affordable and

accessible housing is available in communities has also been considered to be a critical issue (Novek and Menec, 2014).

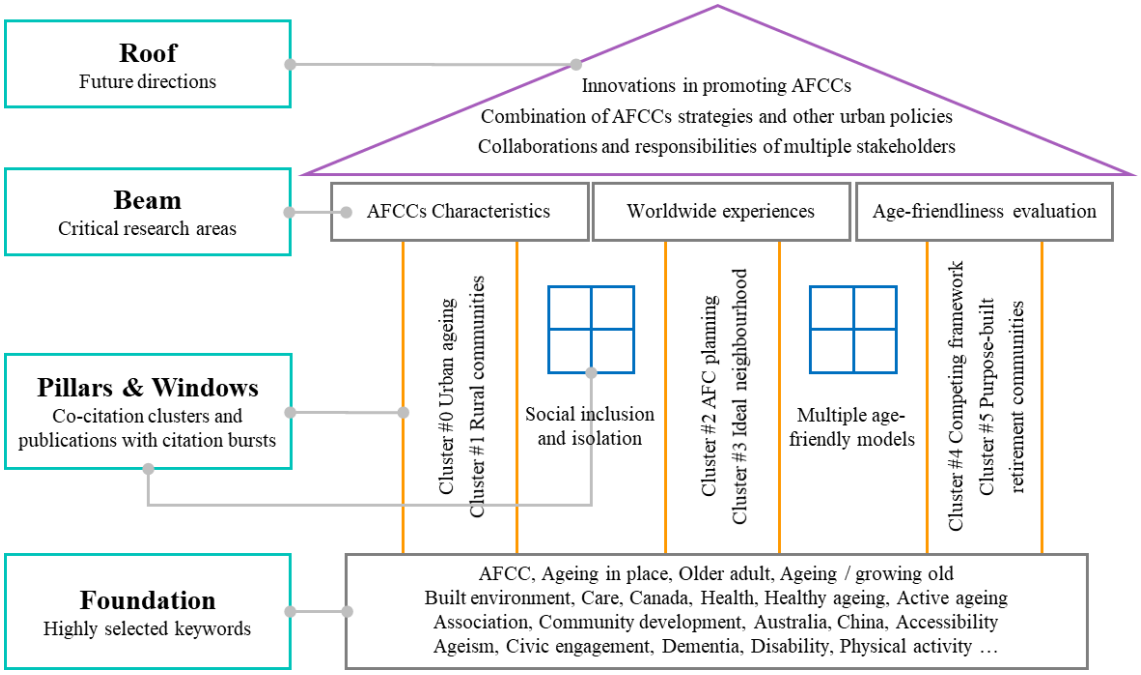


Figure 2-7 A Roadmap for AFCC Research

Numerous studies have been conducted to discuss the application of the AFCC framework introduced by the WHO in various contexts. In supporting the ageing population, planning on macro issues is common and includes issues such as pensions and care services at the national, provincial and local level (Hartt and Biglieri, 2018). Theories, including Kingdon's, which was originally developed to explain pedestrian priorities in the USA, recognise that policy change is continuous and the formulation of specific policies are influenced by three streams, specifically, problem recognition, policy proposals and politics (Neal et al., 2014). Generally, AFCC projects are conducted due to leaders' motivations, rather than seniors' needs from communities.

However, policies that can reduce economic inequalities and provide access to community services are the most important in such projects. Although age-friendly policies must be context-specific and receive continuous support from key political officials who can address related issues, current planning policies that focus on areas, such as sustainable development, quality of life, and growth management are consistent with the concept of age-friendliness (Menec et al., 2014; Neal et al., 2014; Lindenberg and Westendorp, 2015; Hartt and Biglieri, 2018). Therefore, developing AFCC-related policies could serve as an approach to economic growth and sustainability, because new impetus will be provided for business and there will be paid work opportunities, such as housing development or the building of new recreation centres. In addition, supporting senior citizens' ageing in place is considerably cheaper than providing care services in residential facilities; thus, the government's financial burden will be alleviated (Lui et al., 2009; Scharlach and Lehning, 2013). Further studies may also discuss the linkage between age-friendly policies and other social or economic dimensions.

Although senior citizens should be consulted when the AFCC framework is applied, a transformation of the top-down approach does not mean merely promoting a bottom-up approach but working through a collaborative partnership with other stakeholders (Greenfield et al., 2012; Garon et al., 2014). Collaborations among

stakeholders constantly require strong leadership that can enable various groups with a common goal of working together (Clark and Glicksman, 2012; Steels, 2015). However, to date, not all AFCC initiatives have sailed smoothly (Buffel et al., 2014). Experiences from developed countries show that although AFCC initiatives involve cross-section collaborations, most of them have been carried out in the absence of deferral funding or guidance and have often been hampered by limited political authority or economic resources. Furthermore, AFCCs require long term costs to be paid off, whist the local and immediate political costs tend to be acute (Kendig et al., 2014). Under such circumstances, private solutions (such as housing modifications, age-friendly fitness facilities, mixed-use community planning) are apparently emerging (Scharlach, 2012). For example, the *'Age-friendly Buses Project'* and *'Wan Chai Age-friendly Neighbourhood Programme'* in Hong Kong have shown typical collaborations between public and private departments, as well as among various agencies. Thus, policymakers should potentially consider stakeholders' priorities and the mechanism of how the collaborations could be achieved when guidelines from the legal and strategic levels are implemented. Researchers could also conduct case-based studies to explore common goals and conflicts between multiple stakeholders.

Measurement of the age-friendliness of cities and communities had evolved, particularly after 2015, when the WHO introduced core indicators to measure the

age-friendliness of cities and communities. Although site-specific methods have been developed to evaluate programmatic activities, partnership processes and local effects, most studies that have examined AFCCs are still based on descriptive studies (Beard and Montawi, 2015; Giunta and Thomas, 2015; Jackisch et al., 2015; Ruza et al., 2015; Park and Lee, 2018). The absence of environmental measures from existing datasets, adoption of defining indicators, and data collection and calculation are the three main issues encountered by researchers. Relatively little empirical knowledge on how to accurately and appropriately assess the essential characteristics of an age-friendly environment is evident (Kano et al., 2018). When linking the existing survey data to age-friendly indicators, the guidance on interpreting methods and data is quite limited, which means misinterpretation is not easy to prevent (Steels, 2015). Further studies could start by exploring how to accurately interpret survey data and connect with age-friendly indicators.

Previous research has mostly been conducted in developed countries (such as the UK, the USA and the Netherlands) in a Western cultural and social background, which indicates the limited generalisability to high-density cities in the Asia-Pacific region (Wong et al., 2015). Although researchers from non-Western countries have begun to conduct AFCC-related studies, an ageing model that can be applied in developed and developing countries to assist governments and policymakers is still lacking.

Therefore, cross-national studies with a non-Western perspective would further contribute to the literature (Steels, 2015; Park and Lee, 2018). Developing countries are currently experiencing the most rapid demographic change, and 80% of seniors are predicted to reside in low- and middle-income countries by 2050, in comparison to 62% in 2000 (McNicoll, 2002; United Nations et al., 2017). Although several experiences from developed countries can be adopted for developing countries, there is a remarkable congruence between developed and developing countries. The barriers from political and economic domains may severely limit the extent of a community's accomplishment. The lack of standardised assessment tools may also hinder cross-national or inter-country comparisons (Plouffe and Kalache, 2010; Fitzgerald and Caro, 2014; Wong et al., 2015). Further studies are still required to explore the effectiveness and fitness of applying an oriental paradigm in non-Western countries (Chao and Huang, 2016).

2.5 Summary

The past ten years have witnessed a sharp increase in AFCC studies worldwide in different research areas. Ageing is a lifelong process and AFCCs with accessible, healthy and safe environments will benefit senior citizens and the entire society. To determine the development and critical areas of AFCC research, a total of 231 publications are collected and related bibliographic records are entered into *CiteSpace*

to conduct a scientometric review. Based on the data analysis results, three major themes are identified, specifically, characteristics of AFCCs, worldwide experiences in promoting AFCCs, and measurement of cities' and communities' age-friendliness.

Although a variety of studies on AFCCs have been conducted, several topics remain valuable for further discussion. In this chapter, innovations in the approaches to promoting the WHO's AFCC framework, and combinations of AFCC strategies and other urban policies, as well as collaborations and responsibility assignment among multiple stakeholders, are proposed as future research directions. With regard to the roadmap illustrated in the form of a house, researchers' highly selected keywords serve as the foundation; the cluster views of the document co-citation network generated by *CiteSpace* represent the pillars and windows; the critical research areas serve as the beams, and future research directions reflect the roof.

CHAPTER 3 APPLICATIONS OF MULTI-AGENT SYSTEMS IN THE CONSTRUCTION MANAGEMENT AREA

3.1 Introduction

The rise of computation has generated a new field of knowledge referred to as ‘complex systems’. Since complex systems show features of decentralization and adaptation, the multi-agent system (MAS) has developed rapidly based on its capacity to deal with complicated problems regardless of the subject area. From the construction management perspective, almost all projects contain complex systems as multiple stakeholders work together and generally concentrate on different prioritises.

Therefore, this chapter aims at summarising how MASs can be applied in the construction management area, especially at the project level. In addition to the discussions about the characteristics of applying MASs and the future research directions in exploring MASs in the construction management area, a framework for developing agent-based models is proposed, which can provide a reference for simulating key stakeholder relationships in this research.

3.2 An Overview of MAS Applications in Construction Management

The terms used to collect studies from WoS and Scopus were: ‘multi-agent system’ or ‘agent-based modelling’ + ‘construction management’. The ‘document type’ in the

two databases was limited to ‘article’ and ‘review’, while the ‘language’ section was limited to ‘English’. The results from WoS were refined to domains of engineering civil, engineering industrial, engineering multidisciplinary, management, construction building technology and computer science interdisciplinary applications, while in Scopus, they were refined to engineering, business management and accounting, social sciences, decision sciences and multidisciplinary domains. After the duplicate results from WoS and Scopus were merged, a cross-contrast was conducted. *InCites Journal Citation Reports 2019* and *Ei Compendex Source List (January 2020)* were consulted to identify the articles and reviews published in SCI-Expanded, SSCI and Ei Compendex journals. If a work was published in the above-mentioned indexed journals, it was selected for further processing; otherwise, it was excluded. The abstracts of the collected papers were also read to exclude irrelevant ones.

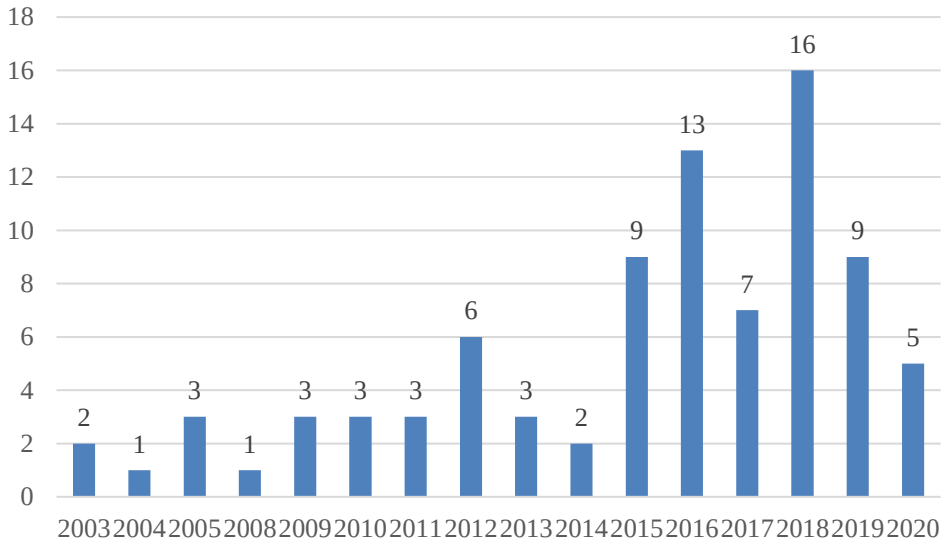


Figure 3-1 Distribution of Selected MAS Publications by Year

A total of 147 articles and reviews were identified after the duplicate results from WoS and Scopus were merged (as of August 2020). Based on the inclusion and exclusion criteria, 86 relevant papers published in SCI-Expanded, SSCI and Ei Compendex journals in relation to applications of MASs in the construction management area were selected for further analysis. Figure 3-1 illustrates the publications by year. Although the collected papers indicated that studies relating to applications of MASs in construction management began as early as in 2003, it was after 2015 that more researchers began to concentrate on the topic. Table 3-1 indicates the journals that published at least two related studies. It can be seen that the journals focus on information technologies in design, engineering, and management of constructed facilities, such as *Automation in Construction*, *Journal of Computing in Civil Engineering*, and *Journal of Construction Engineering and Management* published more articles than others, with 22, 12 and 10 such works, respectively.

According to the collected publications, applications of MASs are included at both the urban and the construction project levels. The former explores behaviours of urban residents and addresses policy implementation and emergency response issues, while the latter provides support to the supply chain management process and assistance toward improving project performance.

Table 3-1 Distribution of Selected MAS Publications by Journal

Journal	Quantity	Percentage
Automation in Construction	22	25.58%
Journal of Computing in Civil Engineering	11	12.79%
Journal of Construction Engineering and Management	10	11.63%
Engineering Construction and Architectural Management	4	4.65%
Complexity	3	3.49%
Safety Science	3	3.49%
Accident Analysis and Prevention	2	2.33%
Advanced Engineering Informatics	2	2.33%
International Journal of Interactive Multimedia and Artificial Intelligence	2	2.33%
International Journal of Project Management	2	2.33%
Journal of Civil Engineering and Management	2	2.33%
Journal of Management in Engineering	2	2.33%
Sustainability	2	2.33%

3.2.1 MAS Applications at the Urban Level

(1) The Behaviours of Urban Residents

With the acceleration of urbanisation worldwide, growing attention has been paid by scholars and practitioners to making cities better places in which to live whereby the question of liveability involves various factors, including but not limited to government policies, residents' behaviours and the allocation of facilities. To explore the residents' behaviours, Goldstein et al. (2004) used an agent-based modelling (ABM) approach to recreate the annual urban extent from 1929 to 2001 of Santa Barbara, California, USA, which described the dynamics and patterns of urbanisation. Torrens and Nara (2007) took advantage of cellular automata (CA) and MASs to develop a model of inner-city gentrification to represent human behaviours in

complex urban systems based on a theoretical foundation that could cater to supply and demand determinants. Osman (2012) used ABM to represent interactions among users, assets, system operators and politicians and indicated how socio-technical aspects could be included within the complex decision-making process of urban infrastructure management. Czamanski and Broitman (2018) built a biology-inspired framework as a basis for the MAS of cities to analyse urban dynamics and obtained a variety of growing patterns. Furthermore, Pan et al. (2020) explored changes in safety liveability in complicated urban systems and concluded that a rapid population increase would have a significant impact on urban safety liveability.

The understanding of settlement patterns of the past, as well as the connection of such patterns to the future, can guide urban planning in a more informative way. For example, Shirzadi Babakan and Taleai (2015) developed an agent-based model to study the relationship between transportation and residential choice of households in Tehran, Iran and found that transport development scenarios significantly affect residence choice and lead to significant changes in residential demand, composition of residents, mean income and car ownership levels. Alghais et al. (2018) conducted targeted surveys among Kuwaiti citizen and non-citizen groups regarding migration likelihood, push and pull factors, spatial preferences for new cities and their opinions on segregation by nationality. Useful answers were extracted and transferred to an

agent-based model to simulate residents' involvement in urban planning. Peña-Guillen (2019) devised a network-based analogy of consolidation that allowed for dynamic simulations to be conducted using the ABM technique and to generate a consolidation process in consideration of spatial and social dimensions in Lima, Peru. Marini et al. (2019) proposed and coupled an agent-based dwelling model to an agent-based population model to explore the evolution of features with regard to the demands of the population and the supply of the housing stock in Lausanne, Switzerland. The models employed were designed to facilitate the decision-making of urban planners and real estate investors seeking to lower risks and make cities more attractive.

(2) The Implementation of Urban Policies

The implementation of policies includes many options, and the MAS has been found to be a powerful tool to model scenarios and evaluate different outcomes before making a decision. Therefore, the MAS has been applied by stakeholders to address potential issues arising from the implementation of policies at the urban level. For example, Mukherjee and Muga (2010) introduced an agent-based model that allowed initial experiments to illustrate the importance of adaptive organisational behaviour under different professional networks and identified two main challenges to adopt sustainable practices in the architecture, engineering, and construction industry, which are the lack of a shared paradigm and the inability to consider adaptive forces. Kong

et al. (2017) integrated CA and ABM to explore the impact of new satellite towns and ecological sensitivity on land-use changes, and their results demonstrated that satellite towns and ecological sensitivity had greater impacts on urban expansion. Ma et al. (2018) also applied the combined CA and ABM model to describe the effects of implementing a linked urban-rural construction land policy in Tianjin, China from 2005 to 2020, and they concluded such policy implementation could both alleviate the occupation speed of arable land and slow the fragmentation of large arable land patches. Motieyan and Mesgari (2018) developed an agent-based model that represented interactions between land use and transportation. In comparison with the detailed plan for the Tehran municipality in Iran, the assessment results indicated that the application of the model decreased differences between the transit-oriented development level and the public transit infrastructure level by 64 percent.

Specifically, in regard to the policies of retrofitting buildings, Stephan and Menassa (2015) developed an agent-based model to explore how social interactions among various stakeholders would help prioritise values and ultimately facilitate optimal decision making on retrofitting a commercial office building. The results indicated that highly connected network structures could facilitate interactions among stakeholders to achieve alignment. Liang et al. (2019) defined the government and residents as agents and modelled their decision-making behaviours regarding the

energy-efficient retrofitting of buildings using principle-agent theory. In that study, a platform based on the model was developed, and the incentive policy was optimised under different circumstances in China. Nägeli et al. (2020) presented a model to explore energy demand and the greenhouse gas emissions of building stocks, especially with regard to how owners' decisions about retrofitting building envelopes and replacing heat systems would affect the development of building stocks in Switzerland according to data generated from 2000 to 2017.

(3) Responses to Emergencies

Despite technological advancements in the architecture, engineering, and construction industries, emergencies in buildings and other public spaces have consistently been an order of magnitude higher than fatalities caused by all other types of natural disasters combined. Therefore, issues regarding responses to emergencies have attracted researchers' attention, and MASs are often applied to model the evacuation process. For instance, Shi et al. (2012) investigated evacuation processes in various fire cases with measurement data as input of the model and discussed the occupant's evacuation behavioural features, the evacuation time, the passage flow rate, together with the strategy for using an escalator as an evacuation passage. Mirahadi et al. (2019) developed a framework by integrating the ABM, fire simulation tools and building information models (BIM). The study's proposed framework was designed to help

designers evaluate evacuation safety performance and analyse a building layout in BIM under various fire scenarios, which would ultimately result in design optimisation based on multiple safety criteria.

In addition to buildings and public spaces, some researchers focus on labour evacuation planning for construction sites. The evacuation conditions in such places are quite different as there are always many temporary works on-site and the number of occupants, spaces and routes for evacuations change every day. Building on different construction scenarios and taking continuous space, discrete-time and modified social force into consideration, Marzouk and Daour (2018) used BIM and MASs to present a framework and implemented the framework into an Egyptian social housing project. The study's proposed framework could calculate the total time of evacuation on each floor and stairs until the assembly point outside the location and investigate ways for workers to leave the site safely.

3.2.2 MAS Applications at the Project Level

Construction projects are influenced by numerous types of hazards, such as organisational, human or economic hazards. Objectives are not always achieved as such hazards cause projects to be plagued by cost overruns, delays and poor performance (Taillandier et al., 2015). The construction management process aims at identifying, analysing and evaluating risks and promoting cooperation among team

members, which is an important factor that contributes to project success. However, the complicated inherent factors, such as the multiplicity of stakeholders and the impact of various hazards, present many challenges to the management process. From the construction management perspective, almost all projects contain complex systems as multiple stakeholders work together and generally concentrate on different prioritises. Construction projects are also characterised by a co-evolution of developments and processes based on self-modification, meaning that the value of a certain project is set in the initial stage but will continue to develop throughout the whole project lifecycle (Son et al., 2015).

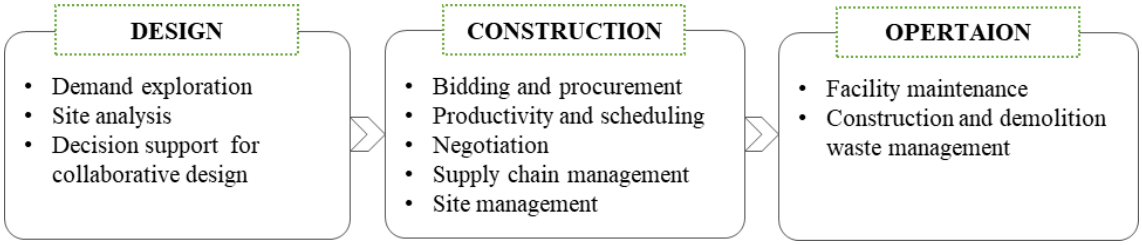


Figure 3-2 MAS Applications in Different Stages of Construction Projects

Therefore, ABM simulation as a bottom-up approach, which takes each agent, its behaviour, and interactions with other agents in a dynamic environment into consideration, would be particularly helpful in stimulating, identifying and analysing issues arising from stakeholders with different backgrounds or that belong to geographically separated teams and work in a dynamic environment. According to the publications generated, MASs can be utilised in different stages during the lifecycle

of construction projects. Figure 3-2 depicts when and how the applications of MASs can deal with different types of issues.

Construction researchers and practitioners have tried to use various techniques to study complex systems. The application of MASs began in the early 21st century when computer-aided design in the construction area was experiencing significant enhancements. More attention was paid after 2015, with a special focus on the management of supply chain and improvement of project performance, which is described in the sections below.

3.3 Utilising MASs to Support the Supply Chain Management

Construction projects are described as long supply chains that extend across various products or service types and interests. Supply chains can significantly affect construction projects due to their ability to deliver construction products (Tah, 2005; Min and Bjornsson, 2008). Supply chain management philosophy has been widely accepted as both an effective and efficient approach to improving construction performance as it helps in the coordination of the distributed decisions of organisations and/or participants regarding flows of material, information, humans and cash (Xue et al., 2005).

3.3.1 Allocation of Human and Material Resources

Construction projects are labour-intensive, and human resources account for 30 to 50 per cent of the total expenses of such projects (Hanna et al., 2007). Unlike materials and equipment that are typically obtained based on the market price and are out of project managers' control, labour costs are the least reliable factor and may be obtained at lower costs through efficient management once the related effects of the factors are understood (Dabirian et al., 2016). Under such circumstances, workers' behavioural diversities are explored by researchers.

Ahn et al. (2013) developed an agent-based model that incorporated mechanisms of workers' formal and social learning to extend the knowledge of workers' absence behaviour. They further suggested how real data collected by questionnaire surveys could be used to simulate workers' behaviours (Ahn and Lee, 2015). Mahjoubpour et al. (2018) studied workers' learning behaviour in a steel structure project and concluded that the social ability to teach and the workers' forgetting factors had major impacts. Wu et al. (2019) developed an integrated ABM and system dynamics (SD) model following a set of implementation approaches to reveal labourers' behavioural diversities and to evaluate their impacts on multinational and cross-culture projects. The study found that such diversities dramatically affect labourers' productivity, work quality and absenteeism rate, resulting in severe project deviations if not adequately

considered. Dabirian et al. (2016) confirmed that the impact of effective factors on the workflow could be predicted as an emergent property based on the interactions among workers, their tasks and the construction sites. Raoufi and Robinson Fayek (2018) proposed a methodology for integrating fuzzy logic and MASs to predict crew motivation and performance and then validated the model using field data collected from a company that was active in various industrial projects in Canada.

MAS applications in dealing with material allocation problems often focus on the operation, maintenance and demolition stage of projects. For example, Dibley et al. (2011) introduced a MAS for facility management that would alleviate the dependency of specialist users, as the system simply required an IFC specification for building and sensor locations. Shen et al. (2012) presented a conceptual framework of the agent-based service-oriented integration method to generate lifecycle information, with a specific focus on facility operation and maintenance management. Soroor et al. (2012) focused on single-product decentralised supply chains and used the ABM method to select the best supplier within the bidding system. Aiming at elaborating how to enhance the recycling of construction materials, Knoeri et al. (2014) utilised MASs to discuss Swiss construction actors' decisions and interactions, analysed key factors that would affect the demand for construction materials and developed scenarios that would lead to the maximal reuse of construction and demolition waste.

Gan and Cheng (2015) conducted a comparative study with both mathematical programming and ABM approaches to identify an appropriate method to analyse the dynamic network of a backfill supply chain by implementing optimisation for backfill recovery among construction sites and a reduction of construction wastes disposed to landfills. Ding et al. (2016) measured and assessed the environmental impact of demolition waste management, and identified the significance of stakeholders' interactions and attitudes, as well as their utilisation of green demolition technologies.

3.3.2 Negotiation and Cooperation among Stakeholders

Conflicts often occur in the context of cooperation among multiple stakeholders, and research has been conducted to address related issues. Xue et al. (2005) designed an agent-based supply chain management coordination framework and integrated organisations into a construction supply chain. The framework was further extended by presenting a relative entropy method to improve the efficiency of agent-based negotiations, especially when prior negotiations failed, or automatic search processes were terminated (Xue et al., 2009). Tah (2005) presented a case with an ABM simulator that allowed organisations to understand the dynamic interactions and interdependencies of supply chains prior to the implementation of management practices. Min and Bjornsson (2008) emphasised the value of real-time information and used an agent-based construction supply chain simulator to demonstrate

human-to-human and computer-to-human interactive simulations. El-Adaway and Kandil (2010) used a formal logic algorithm to simulate the process of legal discourse in construction disputes, presented theoretical foundation and technologies to generate legal arguments related to construction disputes and applied ABM for the resolution. Son and Rojas (2011) introduced an agent-based simulation to evaluate the collaboration in interorganisational networks of construction project teams based on game theory and social network perspectives. Du and El-Gafy (2012) proposed the usage of MAS to explore the interactions between human and organisational factors, and the results indicated the need to understand the social and managerial effects of construction processes. Taillandier et al. (2015) proposed a stochastic multi-agent simulation model that can be used to simulate project progress when integrating the causes of possible risks and their impacts. Hsu et al. (2016) utilised the MAS to explore the complexity of project team member selection, and they suggested that managers should be aware of how interdependent relationships were distributed across a cohort before engaging in any reorganisations. Taillandier et al. (2016) used the MAS to develop a simulation tool that considers risks to assess consequences for each stakeholder of a construction project, and they presented an application for a real case-study at Tlemcen, Algeria. Zhu et al. (2016) used bargaining game theory and time-dependent negotiation strategies with a learning-based method in an agent-based

debt terms' bargaining model to simulate the negotiation process and to improve the efficiency of *Public Private Partnership* projects.

Although a growing number of scholars have applied MASs to investigate issues of cooperation and negotiation, the separately developed models inevitably lead to duplicate development efforts as well as inconsistent theoretical foundations. Therefore, Du et al. (2016) proposed a sharable, universal and open-source database of behaviour models that contain cooperative behaviours in relation to construction problems, and they proved its usefulness for investigating cross-functional cooperation in an engineering, procurement and construction projects.

3.3.3 The Balance between Investment and Budget

Several studies concentrate on the bidding and tendering process of construction projects when exploring investment- and budget-related issues. As contracting firms always face the challenge of selecting a low enough bidding price to win a project and a high enough price to make a satisfactory profit, Asgari et al. (2016) employed ABM to simulate the bidding process and defined makeup behaviours within a market form of contactors. Kog and Yaman (2016) proposed an agent-based contractor pre-qualification model to support a client's decision on contactor selection in the context of a tender management system that contained open, selective limited and

negotiated tendering processes. Awwad et al. (2015) presented an agent-based model for the competitive construction tendering process that allowed observation of the bidding process dynamics: contractors with different characteristics and attitudes competed over projects, learned about others' competitiveness and made bidding decisions. This work was further elaborated by addressing the owner's concern regarding choosing suitable bidding methods by simulating the construction bidding process dynamics of alternative piece-driven tendering approaches that would preserve the transparency of the low-bid method, and rectify the inconvenience of unrealistically low bids (Awwad and Ammoury, 2019).

Other works are typically case- or scenario-based studies. For instance, Jo et al. (2015) discussed the feasibility of public investment projects with an ABM-SD model and applied it in a bridge construction case. Farshchian et al. (2017) simulated the allocation of budget and its effects on projects' progress in various scenarios, including cancelling, suspending or slowing down projects and evaluated project behaviour. The proposed model was designed to help organisations reduce concerns about their portfolio, generate income from projects, and obtain the results of budget limitation strategies more quickly. Farshchian and Heravi (2018) also simulated different conditions and scenarios considering costs inflation during the execution period of construction projects, and they evaluated the model with a theoretical

portfolio that contained 50 projects. Meng et al. (2018) adopted a lifecycle perspective and built an agent-based revenue-sharing negotiation model to focus on time compression. They identified the degree of sympathy preference in inequity aversion, which was found to have an important impact on the time required to reach a consensus, while the degree of jealousy preference showed no obvious impact on the time required to reach negotiation agreement. They further incorporated the contractor's competitive and social welfare preferences into the negotiation game model. The experimental results of that study showed that competitive preferences would make the agent pay more attention to his or her own gains and revenue in the negotiation process, while the sympathy component of social welfare preference had a limited influence on the revenue-sharing coefficient (Meng et al., 2019).

3.4 Employing MASs to Improve Project Performance

The success of a project is identified to connect with both efficiency and effective measures. The former corresponds to strong management and internal organising structure, and the latter refers to user satisfaction (Takim and Akintoye, 2002). The MAS is found to be useful for simulating unforeseen conditions and uncertainties that result in schedule delays and cost overruns and for proposing strategies to deal with problems related to project performance.

3.4.1 Optimisation of Design

Modern architectural designs are influenced by the availability of technology, and the development of construction techniques not only enlarges boundaries but also enables different types of design in both theory and practice (Agirbas, 2019). Architectural design is immensely complicated and has experienced an increase in the methods to generate, rationalise and optimise processes and outcomes. Utilisations of the MAS might aid the design process specifically in the drafting phase (Gerber et al., 2017).

For example, Porter et al. (2014) introduced MAS implementation of BIM for the assessment of infrastructure security and showed that the ABM technique was helpful for both the analysis and design of facilities. Páez-Pérez and Sánchez-Silva (2016) developed an agent-based simulation model to trace an interaction history within the context of a *Public Private Partnership* among the principal, agent, natural environment and its effect on the infrastructure system, and they calculated the utility for each player. Gerber et al. (2017) developed an integrated design methodology based on the MAS that provided designers both geometric and multiple performance feedback and thus assisted them in selecting among design solutions. Younes and Marzouk (2018) developed a detailed agent-based model for the operation of tower cranes that can help in the planning and optimisation of the number, types and locations of tower cranes as well as in the evaluation of the effect on the execution

time. Du et al. (2019) proposed a decision-making evaluation model based on the MAS that considered the dynamic characteristics of design change risks for the whole process of a prefabricated construction project. Song et al. (2019) simultaneously incorporated decisions from the layout planner, the logistics planner and the safety manager to examine the interactions in the determination of an optimal site layout plan, and they validated the agent-based model through a case study. Agirbas (2019) investigated swarm intelligence based on the mathematical rules for the possibilities involved in architectural design and façade construction, and that study compared façade designs in different geometries via multi-agent-based swarm intelligence algorithms. Liu et al. (2020) proposed a multi-agent reinforcement learning system with BIM for path planning, considering both immediate and delayed rewards in clash-free rebar designs for real-world reinforced concrete structures.

During the building design stage, especially for high-rise projects, the parameters of the elevator are quite important as its capacity and running speed should be considered to satisfy future need and MASs can be used to help analyse lift system performance. Jung et al. (2017) used simulation experiments with seven lift options and examined the relationship among system performance, lift car service range and lift traffic type. Xiang et al. (2019) proposed a hybrid elevator planning model that combined discrete-event and agent-based simulation to obtain the average waiting and

spending time-related to up-peak scenarios during a typical day.

3.4.2 Enhancement of Productivity

The length of the construction period has significant effects on the economic, social, and ecological benefits of certain projects, and productivity is one of the most significant factors that influence the length. A number of studies focus on the congestion issue, which causes expensive inefficiencies in work and labour flows that negatively affect performance. More specifically, Watkins et al. (2009) discussed the relationship between congestion and productivity by representing workers and tasks as agents and developing the mathematical formalism to study their interactions. The results indicated that congestion at a construction site could be considered an emergent property. Kim and Kim (2010) developed a MAS to simulate construction operations and applied it to earthmoving activity, considering the traffic flow of the equipment with the congestion of construction vehicles that would affect work efficiency and productivity. Similar work was also performed by Jabri and Zayed (2017) to capture the properties and interactions of model elements, which they verified with a real-world case study. Zhang and Hammad (2012) proposed a MAS that integrated motion planning and real-time environment updates to improve crane operation safety and eliminate delays caused by unpredicted spatial problems at the construction site to improve productivity. Marzouk and Ali (2013) proposed a model

to estimate bored pile productivity considering safety requirements and space availability. Unsal and Taylor (2011) combined MASs with game theory and explored whether precontract partner selection strategies lead to holdup problems, especially those concerned with relationship-specific investments in learning after the introduction of innovation or organisational change throughout a project network. Khanzadi et al. (2018) proposed a hybrid simulation tool, which they implemented in a real concreting project using the SD tool to simulate the various continuous factors affecting labour productivity and the ABM tool to explore the congestions that arises from interactions among different working groups.

Other related studies have discussed improvements in productivity in terms of specific construction elements. For instance, Matejević et al. (2018) presented an original model with ABM and discrete event simulation methods to predict the productivity of reinforced concrete slabs. Wang et al. (2018) embedded the heuristic optimisation algorithm within a MAS schema to synchronise the production scheduling and resource allocation. Implementation of the model indicated that it would help project managers predict and improve the value of labour productivity. Abou Yassin et al. (2020) stimulated and optimised the printing of retaining and shear walls, and they identified a large gap between the capacity of concrete and steel 3D printing that mainly resulted from the slow rate of steel printing or welding.

3.4.3 Workers' Safety Performance

Apart from the issues related to workflow and products, safety performance is another factor that can impact both the cost-efficiency and the performance of a certain project. It is a general belief that the more safety investment, the better the safety performance of a project. However, this belief is also one of the main factors that have led to the construction industry's reputation for poor safety records (Awwad et al., 2017).

Unlike the top-down approach that starts with a theory of the relationship between safety investment and performance followed by researchers' specific hypotheses to be tested with equation-based modelling methods, Goh and Askar Ali (2016) utilised a hybrid framework to represent the various components of construction activities and conducted a hypothetical earthmoving case study to show that safety behaviours can be considered during planning. Choi and Lee (2018) developed an agent-based model that incorporated the socio-cognitive process of workers' safety behaviours and demonstrated that safety management interventions such as the strictness and frequency of management feedback and project identification contributed to decreasing the incident rate. Li et al. (2018) built a three-layer model that included system performance, agent interaction and agent attributes to study the unsafe behaviours of construction teams and to manage the challenges of complexity through a case with a realistic background. Lu et al. (2016) provided a practical framework by

using the MAS to investigate how safety investments with different parameters could affect safety performance. The results of that study illustrated that proactive construction management system assistance, safety supervisors' inspection and co-workers being responsible for one another's safety were three effective investments toward improving safety performance. Awwad et al. (2017) presented an agent-based model that combined stakeholders in a market environment and explored their interactions in the bidding and construction stages of a project. That model made it possible to observe emerging safety patterns in a given environment based on the potential reformative actions initiated by various stakeholders. Zhang et al. (2019) modelled on-site interactions between workers and management teams, distinguished marginal behaviours at multiple levels, associated worker behaviours with their respective backgrounds, and recognised the impacts of such heterogeneity on the overall safety performance of a construction team. The results of that study led to the suggestions that management teams should emphasise and cultivate the leadership role among supervisors and that senior managers should regularly be involved in safety activities. Ji et al. (2019) simulated workers in a construction site with a crane hazard, and the results indicated that combined co-worker support actions, such as warning co-workers to leave hazardous areas and reminding them to wear personal protective equipment, could effectively reduce the severity of recordable, lost-time

and fatal incidents whereas a single action would be more likely to work when nonfatal incidents occurred.

3.5 Characteristics of MASs Applications in Construction Management

3.5.1 Strengths and Weaknesses of Current Applications

The way to conceptualise and model the construction systems has changed from aggregate to disaggregate and from static to dynamic (Crooks and Heppenstall, 2012), and the desire to model the world in a way that is more faithful to the real world has motivated the development of MAS applications (Macal, 2016). Compared with equation-based models, agent-based models are flexible, process-oriented and obtain more detailed simulation results. To be more specific, ‘flexible’ refers to the idea that the MAS can capture a variety of behaviours for agents, operate when decisions are made based on probability, and at the same time maintain a balance between flexibility and precision; ‘Process-oriented’ represents a focus on how agents apply information and interact with each other and the environment, which is usually ignored by equation-based models that rely on parameters to abstract problems (Son et al., 2015); While ‘detailed’ refers to the results generated by MASs on both the individual and aggregate levels since the models operate by simulating each agent and their decisions.

Based on the current MAS applications in the construction management area, when a

system involves multi-human or multi-organisation decision-making in the transition, and the status is determined significantly due to the relationships among multiple agents, the MAS will be of great help. Since the MAS can act separately and be executed by numerous agents, it is suitable for complicated interactions including cooperation, coordination and consensus. The MAS is also robust because it does not rely on a centralised control centre. Hence, a complex problem can be divided into smaller ones and be assigned to multiple agents for parallel processing, especially when individual behaviour is non-linear and the interactions of agents can generate network effects (Bonabeau, 2002; Liang et al., 2016). The MAS is also helpful when the decision-making process is not purely technical but includes social and political needs and constraints that should be embedded, rather than modelled as externalities (Osman, 2012). In addition, the ABM technique can be utilised to identify a suitable level for exploration when the complexity of a system is unknown as it provides a framework to integrate the complexity of agents.

Although the MAS has some benefits over other modelling techniques, there are some contexts in which the cost of building an agent-based model exceeds the benefits. First, applying the MAS could be more costly and time-consuming than researchers and practitioners might imagine. Second, the abstraction of a certain phenomenon requires careful consideration: if the level of abstraction is too simple, then important

variables may be ignored; if too many details are included, then the model may have a larger number of constraints and become quite complicated (Crooks and Heppenstall, 2012). Third, even though the power of computing increases, the high computational requirements of the MAS remain a limitation when the systems are large. Drawbacks such as the validating difficulty, the practicality of involving large stakeholder groups and the lack of generality are also quite obvious issues that are worthy of consideration (Osman, 2012; Son et al., 2015; Liang et al., 2019). Finally, data unavailability is a general problem that has been noted by many researchers in various fields, with impacts on both the accuracy and performance of agent-based simulation models. Table 3-2 lists the above-mentioned advantages and disadvantages of applying MASs in the construction management area.

Table 3-2 A Summary of Pros and Cons for Applying MASs

Pros	Cons
Deal with relationships of multi-human or multi-organisation	Costly and time-consuming
Act separately and be executed by agents	Difficulties in the abstraction of a phenomenon
Robust, does not rely on the centralised control	High computational requirements for large MASs
Embrace social and political needs and constrains apart from technical ones	Difficulties in the validation
Find a suitable exploration level	Unavailability of data

3.5.2 A Framework for Developing Agent-Based Models

Based on current MAS applications in the construction management area, a five-step framework can be followed to develop an agent-based model when dealing with

complicated issues. Figure 3-3 illustrates the five steps, starting with (1) the problem identification, followed by (2) components confirmation, (3) model formulation and experimentation, (4) data analysis and model validation, and ending with (5) model application.

During the component confirmation step after identifying the problem, the attributes and behaviours of multiple agents, as well as the conditions of the environment, should be confirmed. The information sharing and interactions among agents, together with interactions between the agents and the environment, serve as the core of the agent-based model. The attributes, behaviours and interactions should be computer-understandable. The control unit in the formalisation and experimentation step is used to ensure the smooth operation of the MAS, with the agent scheduling section used to allocate resources for agents, the state control section used to monitor changes in each element in the system, and the clock section used to ensure that the system runs under certain time sequences, such as days, months or years (Pan et al., 2020). The data obtained from the third step are analysed by statistical methods and visualised, mainly using tables and diagrams. Related analysing results are employed to adjust the former two steps before applying the model to address specific issues in the construction area.

MASs-related studies are mostly conducted from the computer science perspective,

which means that software architecture is inevitably given more attention than the analysis of the proposed topics. In addition to the five steps of developing an agent-based model, Figure 3-3 also depicts the connections between the steps and where future work could be conducted.

As MAS applications are gradually accepted by researchers and practitioners from the construction field, integrating construction-domain knowledge in MASs, especially during the steps of component confirmation and model formulation and experimentation, is an important concern for researchers apart from investigating the mechanism of collaboration. In the meantime, hybrid modelling poses challenges for researchers and practitioners to determine how the MAS can work effectively with other simulating and modelling approaches. Taking into consideration the complexity and dynamics of construction problems, issues such as the empowerment of agents and the development of agents' self-learning and adaptive capacities regarding construction applications, together with the legal affairs of agents' contracting and agent-based engineering services could be further explored (Ren and Anumba, 2004; Tah, 2005; Ding et al., 2016).

The field related to MASs has evolved slowly but steadily during the past few decades, with a tendency toward the development of large-scale applications that are capable of supporting policy analysis and decision-making processes (Macal, 2016). Therefore,

exploring better ways for how MASs provide information for policymakers in the construction area is still needed. Further efforts could also generate new MAS techniques as well as evolutionary computing methods derived from artificial intelligence research (Tah, 2005). For example, a potential research direction would be to integrate big data from buildings with geographic information systems to facilitate use of the building information and the physical simulation space such that the models can become more consistent with the real world Providing support for real-time management issues will also be a helpful direction for practitioners.

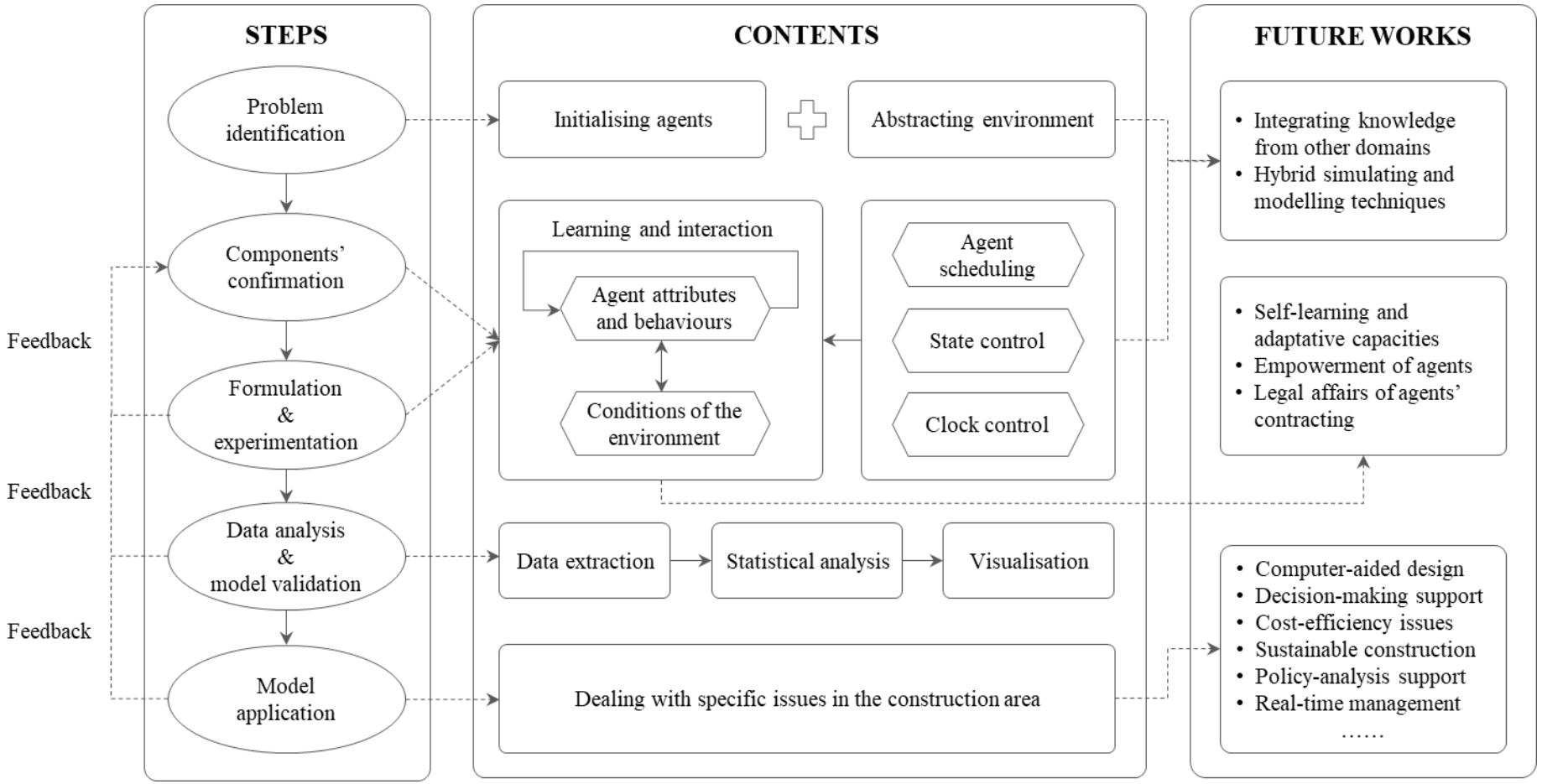


Figure 3-3 A Framework for Developing Agent-Based Models

3.6 Summary

MAS applications are recognised as being among the most promising paradigms for conducting detailed investigations and providing reliable problem-solving methods, and such applications make it possible for researchers and practitioners to better understand complex systems in the construction management area. In this chapter, the two levels of applications are summarised, the uses of MASs to support the supply chain management process and to improve project performance are identified, the characteristics of applying MASs are analysed. A framework for developing agent-based models is also proposed, which will be referred to when conducting simulations of key stakeholders' relationships in the following part of this research.

The MAS is a powerful tool that provides bottom-up understandings of complex consequences in the construction management area. However, the MAS still faces challenges at the implementation level, including but not limited to the difficulties in data acquisition, model validation, and outcome assessment. Here, further study of these issues begins with a focus on combining construction domain knowledge with MASs, making hybrid modelling more efficient, and exploring how MASs can better support policy analysis and decision-making issues.

CHAPTER 4 RESEARCH METHODOLOGY

4.1 Introduction

This chapter presents the research methods and analytical tools employed in the study. To identify key stakeholders and CSFs for AFC projects, a literature review on studies related to AFCs is conducted. Then, the Delphi method is applied to screen the extracted key stakeholders and CSFs. Three focus group discussions are conducted to explore key stakeholders' concerns on CSFs during the briefing stage of AFC projects. After the data collection process, a two-mode network is established to explore the relationships among key stakeholders and potential conflicts that could occur because of key stakeholders' different concerns.

To explore strategies of mitigating conflicts among stakeholders during the briefing stage, the ABM technique is applied to simulate a consensus building process in a real case. Suggestions for key stakeholders are proposed and validated considering the simulation results. On the basis of the agent-based simulation, the general components and variables included in the MAP for the briefing stage of AFC projects are summarised, and a three-tiered MAP is designed.

4.2 Research Methods

4.2.1 Literature Review

(1) Scientometric Analysis

Scientometrics is related to bibliometrics and informetrics and is defined as ‘science about science’, which covers the quantitative methods for analysing science and research processes and has been used in knowledge management (Mooghali et al., 2012; Mryglod et al., 2018). As an academic area, this concept has been developed by prominent researchers, such as Merton (1973, 1976), Garfield (1972, 1979) and Price (1986). Scientometric analysis is an important approach to assess scientific publications by identifying emerging study areas and tracking the development of research in certain time periods, regions or institutions (Mooghali et al., 2012). Normative and descriptive methods are the two generally applied methods in conducting a scientometric analysis. The former perspective aims to establish boundaries, rules and heuristics to ensure progress in certain disciplines, whereas the latter emphasises researchers’ accomplishment in specific areas (Neufeld et al., 2007). This study adopts the descriptive method, which is better suited than other methods for identifying critical areas in the range of publications on AFCC studies.

Numerous visualisation tools, such as *CitNetExplorer*, *VOSviewer* and *CiteSpace*, are available for completing the scientometric analysis process. Compared with other

software, *CiteSpace* is more powerful for visualising patterns of the scientific literature, which facilitates an understating of research trends and the discovery of research frontiers (Ekanayake et al., 2019; Su et al., 2019). Hence, as a tool for progressive knowledge domain visualisation (Chen, 2004), *CiteSpace* is selected to conduct the co-citation analysis in this study; the latest version (CiteSpace 5.5.R2, 64-bit, updated on September 16, 2019) is used for analysis and visualisation.

(2) Document Analysis

Document analysis is conducted as a systematic procedure to obtain information from text and images that have been recorded generally without researchers' interventions (Bowen, 2009). Age-friendly related concepts were first introduced by the WHO, and political forces have always played an important role in fostering age-friendly initiatives based on the current experiences of developed countries and areas. Therefore, documents of and policies announced by the WHO and other international organisations (e.g., The United Nations, AARP Livable Communities in the USA), as well as standards and guidelines introduced by central and local governments in China, should not be neglected in conducting AFCs-related research. In addition, the *Global Network* provides various types of documentation. In this regard, document analysis serves as a major qualitative method for conducting the in-depth analysis of existing AFCs-related data.

4.2.2 Delphi Method

The Delphi method is accepted as an approach for achieving convergence of expert opinion for certain topics, and it has been applied in a variety of fields, such as needs assessment, program planning and policy determination. A notable characteristic of the Delphi method is that the process employs subject anonymity; thus, the effects exerted by dominant individuals are reduced (Hsu and Sandford, 2007).

In this study, the initial lists of six key stakeholders and 28 CSFs were extracted and categorised by the author in February 2019 through a targeted literature review and document analysis. Then, 15 experts were invited to join a Delphi panel for screening the extracted key stakeholders and CSFs. The panel members were asked to add what they considered to be missing, remove or combine what they thought was repetitive or unimportant and evaluate whether the four categories were suitable to accommodate the identified CSFs. Eight of the invited experts returned their feedback by the end of March 2019, either through email, telephone or face-to-face discussion with the author. The eight experts had no less than ten years of experience in the construction management, urban planning or social policy area. After the first-round screening by the eight responsive experts, the author adjusted the stakeholders and CSFs according to the comments collected and sent the revised list for second-round screening. Two lists of seven stakeholders and 22 CSFs were finalised in mid-April 2019.

After the two rounds of Delphi-panel screening, a pilot study was conducted with four PhD candidates and one research assistant from a university on April 18 in 2019. The participants were familiar with AFC-related topics, and their research areas included construction management, urban planning, architecture and social science. The five participants' mother tongue was Chinese, and they had a good command of English. The participants were asked to read the instructions and complete the evaluation of the relationship between key stakeholders and CSFs (the results generated from the pilot study were not used for further analysis). Potential misunderstandings of the key stakeholders' roles and CSFs were highlighted, after which the question of how to clarify them was discussed. Given that the survey was to be conducted in mainland China, the pilot study participants were also asked whether the Chinese translations of the key stakeholders and CSFs were accurate.

4.2.3 Focus Group Method

The focus group method is widely used in qualitative research, not only because it can generate complex information at a low cost and with a minimum amount of time, but also due to its capacity to encourage a variety of responses, which provides a better understanding of participants' attitudes regarding the proposed research topic (Liamputtong, 2011). Focus group discussions are helpful for getting to know the causes and effects of existing issues. It is also useful to verify whether differences

exist between people's stated preferences and what they actually prefer (Prasad and Garcia, 2017). To fully explore the topic and avoid exhausting participants, the length of a focus group discussion is typically between 60 and 90 minutes.

In this study, three focus groups were formed separately from May to July 2019. Due to practical difficulties, not all key stakeholders could be involved in the focus groups. The first focus group discussion was conducted in Shenzhen on May 18, with seven participants who are urban planners and researchers from various institutions. The second focus group discussion was conducted in Guangzhou on May 31, with seven participants from the same architecture and engineering design company. This company has been responsible for several construction projects in communities and facilities for senior citizens during the past ten years, and the company's focus is the architectural and interior design. The third focus group discussion was organised in Qingdao on July 20 with seven participants: one senior citizen, one caregiver, one urban planner, two architects and two real estate researchers.

The relationship among seven key stakeholders and 22 CSFs identified was evaluated using a 7×22 matrix with 154 interactions. A five-point Likert scale was used to indicate the extent to which the CSFs will be considered by the key stakeholders when making decisions during the briefing stage of AFC projects. The participants were asked to use 1 to 5 when evaluating the concerns on CSFs (1 = key stakeholders 'will

not consider CSFs in most cases'; 2 = key stakeholders 'will not consider CSFs in some specific cases'; 3 = key stakeholders 'hold a neutral attitude towards CSFs'; 4 = key stakeholders 'will consider CSFs in some specific cases' and 5 = key stakeholders 'will consider CSFs in most cases').

Each focus group discussion typically included the following steps. First, the Delphi method was applied to collect individual evaluations from participants regarding the CSFs considered by different key stakeholders. This step would take one hour. Second, an open discussion was conducted to reach a consensus among the participants. This step would take two hours depending on the differences among the evaluation results that were made during the individual session. Third, evaluation matrices of the relationships among key stakeholders and CSFs were obtained.

4.2.4 Case Study

The case study approach provides a unique way to obtain a case-based understanding of research questions; this method is widely adopted in the construction area. In this study, Shenzhen, Guangzhou, and Qingdao are selected as the target cities for the focus group discussions, while a real case in Shanghai is chosen to conduct the agent-based simulation. The cities are chosen based on a series of criteria including but not limited to the city's GDP level, geographical location, population and political administration status in China's tiered city system (Hernandez and Bland, 2018). The

projected population in the coming decade and the conditions for carrying out age-friendly initiatives are also considered (Table 4-1).

Table 4-1 Targeted Case Study Cities

City	2019 GDP (Billion ¥)	Population (Million)		Location	Tier of the City	Progress of AFC Initiatives
		2019*	Gain till 2030			
Shenzhen	2692.709	13.44	2.2	Southern	2	Started around 2015
Guangzhou	2362.860	15.31	1.2	Southern	1	Started around 2018
Qingdao	1174.131	9.50	Not applicable	Eastern	2	Started from 2010
Shanghai	3815.532	24.28	2.0	Eastern	1	Started from 2013

* The population of 2019 includes native and transient ones

Qingdao is a coastal city that is known as 'One of the most ten liveable cities in China', and the city has conducted age-friendly initiatives since 2010. Many seniors who work in other cities would like to move to Qingdao after retirement (Zhao, 2019). The relatively sound care system for seniors in Qingdao facilities key stakeholders to consider the CSFs more thoroughly when promoting AFC projects. Although age-friendly initiatives in Shenzhen and Guangzhou have been conducted for only a short time, the experiences of these two cities in promoting a liveable environment are useful for the current study. Since these two cities have always been chosen by the central government of China to conduct pilot projects, key stakeholders are more open to new initiatives and can provide creative ideas for further consideration. The above-mentioned properties of these three cities are, therefore, helpful when conducting focus group discussions to obtain an understanding of key stakeholders in

China and to discuss potential challenges.

Shanghai is the first Chinese city that encountered the challenges of population ageing, compared with worldwide mega-cities, such as Tokyo (22.2% in 2016), New York (12.1% in 2016) or London (11.6 in 2016%), Shanghai still has a relatively large ageing population, which accounted for 14.3% of the total population in 2017 (Shanghai Municipal Statistics Bureau, 2018). Age-friendly initiatives in Shanghai began in 2013, and social media has reported many projects that other cities can follow. In addition, the pilot project in Shanghai was selected by the WHO (2015) to build core indicators for evaluating the age-friendliness of cities. Therefore, a real community project in Shanghai has been chosen to conduct the agent-based simulation and to verify the effectiveness of the proposed strategies. Through the experiences obtained from the above four cities, the aim of the current study is that other cities with similar situations in mainland China will benefit.

4.3 Analytical Tools

4.3.1 Social Network Analysis (SNA)

SNA is as an interdisciplinary concept from sociology and anthropology that uses nodes and links to illustrate the relationships among different key stakeholders in the construction area. In the SNA graph, the nodes represent different key stakeholders, and the links display the relationships among them. The commercial software,

NetMiner 4.3, is used to analyse and visualise the collected data. Apart from the nodes and links, additional information can be illustrated in the output contents: for example, the shape and colour indicate types of key stakeholders, while the length and the width of links suggest the closeness of the relationships.

A two-mode social network model is beneficial in representing the relationship between two groups, and it has been proposed to evaluate the relationship between individuals and their related attributes (Liang et al., 2017). Yang (2014) summarised a five-step process of conducting SNA in the construction management domain: (1) identify the network of key stakeholders, (2) assess meaningful and actionable relationships, (3) visualise the network using various software packages, (4) analyse the network data using quantitative analysis methods and (5) present the results.

The two-mode data involve two analytical techniques (Borgatti and Everett, 1997): The first analytical technique converts the two-mode network into a one-mode network through a projection matrix, for which the full range of analytical methods can be applied. The second analytical technique uses methods that can work directly with two-mode data. Although some studies have assumed that the former causes information loss, Everett and Borgatti (2013) showed that data are not necessarily lost provided that dual-projection methods are used. In addition, such approaches often have conceptual advantages over direct ones. Liang et al. (2017) conducted a case

study of green retrofitting in China using projection methods to analyse a two-mode network. The results generated indicated that these methods are generally safe to use.

Therefore, this study adopted the projection method when converting the two-mode network data into one-mode data. The degree, betweenness and eigenvector centralities were used to analyse key stakeholders' concerns on CSFs. Cluster analysis was applied to categorise key stakeholders, particularly by considering their similarities at the briefing stage of AFC projects.

4.3.2 Agent-Based Modelling (ABM)

In recent years, there has been a transition from the use of rational actor models to agent-based models, and the top-down macro decision-making in the construction area has gradually changed to bottom-up micro-stimulation (Billari et al., 2006). ABM is considered to be a form of computational modelling; it works to model real-world phenomena in terms of agents and their interactions (Wilensky and Rand, 2015). In a MAS, an agent is usually an autonomous computational individual or object with special attributes and actions, and a common feature of MASs is that individual agents act in accordance to certain rules of behaviour, policies or other social, economic and environmental factors. An agent may lack the necessary resources, information and capabilities in attempting to solve problems, however, interactions between each identifiable agent provide aggregated attributes that can facilitate decision-making

procedures afterwards (Motieyan and Mesgari, 2018).

As the WHO guidelines emphasise seniors' bottom-up participation in the building of AFCs, as a bottom-up approach, ABM provides an opportunity to understand and manage the relationships of multiple stakeholders affected by various factors that are difficult to simulate. In addition, ABM can couple with top-down models and policies related to AFC projects (Motieyan and Mesgari, 2018) despite difficulties in the abstraction of phenomena and high computational requirements for large agent-based models. In this study, the ABM technique is applied to simulate key stakeholders' consensus building process and to serve as the foundation for designing the MAP for the briefing stage of AFC projects.

4.4 Summary

This chapter first summarises the research methods and analytical tools to be applied and then describes them separately in detail. A literature review is performed to understand the current research trends, which provides fundamental information for this study. The Delphi method and focus group methodology are used during the data collection process, while a case study provides the opportunity to understand key stakeholder relationships in practice. The analytical tools applied to conduct the data analysis are SNA and ABM, which provide quantitative references to facilitate an understating of key stakeholders' concerns in AFC projects.

CHAPTER 5 KEY STAKEHOLDERS' CONCERNS ON CRITICAL SUCCESS FACTORS FOR AGE-FRIENDLY COMMUNITY PROJECTS AT THE BRIEFING STAGE[1]

5.1 Introduction

This chapter examines the relationship among key stakeholders with SNA, identifies characteristics of Chinese stakeholders and their concerns on CSFs for AFC projects, discusses the challenges of AFC projects in urban China and proposes potential strategies to mitigate conflicts among key stakeholders at the briefing stage. The outcomes illustrate the similarities of key stakeholders, their influences and concerns on CSFs for AFC projects.

5.2 Key Stakeholders Engaged in AFC Projects

5.2.1 Identification of Key Stakeholders and Their Roles

RIBA (2020) defined project stakeholders as any party outside the project team who would influence the design or create a constraint for the project. Therefore, planning departments, building control teams, utility companies, community groups,

[1] Parts of this chapter were published by *Engineering, Construction and Architectural Management* in the paper entitled 'Understanding stakeholders' concerns of age-friendly communities at the briefing stage: A preliminary study in urban China'. An early version of the paper won the 'Best Paper Award' from the *International Conference on Construction and Real Estate Management* in 2020.

environmental bodies, specialist interest groups, insurance and warranty providers are all potential parties that might be included. A key stakeholder is created in a negotiation process when an entity controls one or more critical resources (Brouthers and Bamossy, 1997). There are potentially many types of key stakeholders, which can be a group of people or an organisation that has direct or indirect influences on the construction process of a project (Freeman, 2010; Hu, Xia, et al., 2015).

In regard to AFC projects, Chan and Cao (2015) clarified that key stakeholders in the implementation of age-friendly initiatives in Hong Kong are the elderly people, policymaking institutions and advisory boards, district councils, universities and research institutions, business or private sectors, as well as NGOs and other social groups. Sun et al. (2017) compared two different modes of promoting AFC projects in Hong Kong and Chiayi City in Taiwan, and they indicated the major role of academic institutions. Cho and Kim (2016) used Jangsu village in Seoul, South Korea as an example to elucidate the contributions of neighbourhood social capital when coupling age-friendliness with urban regeneration and discussing local-specific problems. Experiences from Western countries, such as Canada, the USA, the Netherlands and Belgium, highlight the power of senior citizens and NGOs (Garon et al., 2014; Menec et al., 2014; Hu, Xia, et al., 2015).

Table 5-1 lists key stakeholders engaged in AFC projects.

Table 5-1 Key Stakeholders Engaged in AFC Projects

Code	Key Stakeholder	Source
S1	Senior citizens	Garon et al. (2014); Liddle et al. (2014); Chan and Cao (2015); Greenfield et al. (2015); Lowen et al. (2015); Moulaert and Garon (2015); Steels (2015); Chan et al. (2016); Cho and Kim (2016); Orpana et al. (2016); Sixsmith et al. (2017); Buffel and Phillipson (2018); Buffel (2019); Lin et al. (2019)
S2	Caregivers	Garon et al. (2014); Cho and Kim (2016); Sun et al. (2017)
S3	Local government and policymaking institutions	Garon et al. (2014); Liddle et al. (2014); Menec et al. (2014); Chan and Cao (2015); Greenfield et al. (2015); Lowen et al. (2015); Moulaert and Garon (2015); Spina and Menec (2015); Steels (2015); Chan et al. (2016); Cho and Kim (2016); Orpana et al. (2016); Gudowsky et al. (2017); Sun et al. (2017); Greenfield (2018); Lin et al. (2019)
S4	Research institutions	Glicksman et al. (2014); Chan and Cao (2015); Moulaert and Garon (2015); Cho and Kim (2016); Orpana et al. (2016); Sun et al. (2017); Liddle et al. (2014); Neal et al. (2014); Lin et al. (2019)
S5	Project investors and real estate developers	Garon et al. (2014); Chan and Cao (2015); Greenfield et al. (2015)
S6	Urban planners, architects and interior designers	Cho and Kim (2016); Arentshorst and Peine (2018)
S7	NGOs	Garon et al. (2014); Menec et al. (2014); Chan and Cao (2015); Greenfield et al. (2015); Moulaert and Garon (2015); Steels (2015); Chan et al. (2016); Cho and Kim (2016); Orpana et al. (2016); Sixsmith et al. (2017); Sun et al. (2017); Greenfield (2018)

Corresponding details of each key stakeholder are explained as follows.

S1–Senior citizens: People aged 60 years old or over who live in their own home in the community and rely on both family care and community-based services.

S2–Caregivers: Caregiver can be professionals, such as doctors or nurses, who are familiar with geriatric diseases and knows how to take care of seniors with limited ADL levels. Additionally, caregivers can be non-professionals, such as relatives or friends of senior citizens, and they should typically be at least 18 years old but below 60 years old. In this study, caregivers should also spend at least three months annually living with senior relatives in the same city.

S3–Local government and policymaking institutions: This kind of key stakeholder includes members from organisations such as the national or local *Committee on Ageing*, the *Home Affairs Bureau*, or the *Planning and Natural Resources Bureau*.

S4–Research institutions: These institutions involve researchers who engage in real estate, affordable housing, construction management, gerontology, geriatrics, geriatric nursing, sociology and other related studies.

S5–Project investors and real estate developers: This kind of key stakeholder includes institutions or groups of people who provide financial support for AFC projects, companies or groups of people who are responsible for real estate development work.

S6–Urban planners, architects and interior designers: These professionals form companies or groups that are responsible for the planning and designing work.

S7–NGOs: This kind of key stakeholder includes members of the *Ageing Development Foundation*, the *Retired Staff Committee*, the *Volunteer Association*, or other community-based groups.

When conducting the focus group discussions, all participants were asked which description of the seven listed key stakeholders could best indicate their roles in AFC projects according to their research and practical experiences. Given that some participants have worked at more than one institution, they were encouraged to make two choices and to highlight the most suitable one based on their understanding. Table 5-2 shows the details of the participants' occupations and their choices pertaining to the descriptions of key stakeholders.

Table 5-2 Details of Participants in Focus Group Discussions

Participants' No.		**Occupation / Years of Experiences**	**Roles as Key Stakeholders in AFC Projects**	
			First Choice	**Second Choice**
First Round (May 18, 2019)	1	Urban planner / 3.5 years	S6	Not applicable
	2	Urban planner / 1.5 years	S6	Not applicable
	3	Research assistant in the real estate area / 2 years	S4	Not applicable
	4	Urban planner / 1.5 years	S6	Not applicable
	5	Strategic planner and policy researcher for the construction company / 1 year	S5	Not applicable

(Continued)

Participants' No.		Occupation / Years of Experiences	Roles as Key Stakeholders in AFC Projects	
			First Choice	Second Choice
First Round (May 18, 2019)	6	Strategic planner and policy researcher for the municipal government / 0.5 year Researcher in the urban planning area / 3 years	S3	S4
	7	Researcher in the housing and construction management area / 3 years	S4	Not applicable
Second Round (May 31, 2019)	1	Architect / 8 years	S6	Not applicable
	2	Interior designer / 8 years	S6	Not applicable
	3	Interior designer / 0.5 year	S6	Not applicable
	4	Architect / 4 years	S6	Not applicable
	5	Interior designer / 3 years	S6	Not applicable
	6	Architect / 6 years	S6	Not applicable
	7	Interior designer / 4 years	S6	Not applicable
Third Round (July 20. 2019)	1	Urban planner / 7 years Lecturer in architecture and urban planning area / 2 years	S6	S4
	2	Real estate developer / 5 years	S5	Not applicable
	3	Architect / 14 years	S6	Not applicable
	4	Retired administrative staff / 7 years Caregiver of an Alzheimer's patient (Non-professional) / 10 years	S2	S1
	5	Retired lecturer / 5 years	S1	Not applicable
	6	Chinese People's Political Consultative Conference (CPPCC) member of a district / 4 years Associate professor in the architecture area / 8 years	S3	S4
	7	Lecturer in the architecture area / 10 years	S4	S6

5.2.2 Importance of Stakeholder Analysis at the Briefing Stage

Briefing is the first step in the design process during which client requirements are defined, clarified, and articulated and major commitments of resources are made (Kelly and Duerk, 2002; Olatokun and Pathirage, 2015; Yu and Shen, 2015). The RIBA combined 'strategic definition' and 'preparation and briefing' as the pre-design period of a construction project (RIBA, 2020). This study takes RIBA's pre-design period as the 'briefing stage', and mainly focuses on exploring key stakeholders' concerns and defining their responsibilities.

In the briefing stage, the participants are typically from different parties because this session comprises communication and information exchange among clients, developers, architects, consultants and users of facilities (Olatokun and Pathirage, 2015). These parties are familiar with their fields of specialisations but not with all aspects related to projects. However, each party may need to make decisions out of their speciality in many cases (Kelly and Duerk, 2002). Although a consensus has been reached that the briefing stage is critical, limited time and attention are allocated to this stage (Olatokun and Pathirage, 2015). Therefore, project performance is usually impacted by an inadequate scope definition (Yu and Shen, 2015).

Mitchell et al. (1997) proposed stakeholder theory, which indicated that in stakeholder analysis, the legitimacy of relationships, urgency of demands, and power to influence

should be considered three important attributes of stakeholders. To ensure positive outcomes for construction projects, stakeholders should be carefully understood and managed (Yang et al., 2009). Stakeholder analysis helps to clarify issues such as who the key stakeholders are, how they are being managed, and how constraints or risks are to be addressed (RIBA, 2020). Therefore, stakeholder analysis at the project briefing stage, which is as an essential component of the stakeholder management process, should be conducted because the decisions that are made based on the analysis results will profoundly affect the ensuing construction process (Jepsen and Eskerod, 2009; Freeman, 2010; Hu, Xia, et al., 2015; Silverstein et al., 2019). For AFC projects, stakeholder analysis enables key stakeholders to understand the requirements of others and determine which requirements should be prioritised; and provides opportunities for stakeholders to mitigate potential conflicts and avoid negative impacts. Furthermore, at the briefing stage, stakeholder analysis can compensate for the limited information generated when starting AFC projects.

Although studies on stakeholder analysis have not depicted a complete image of practical methods, various approaches have become beneficial in facilitating the analysis process, such as focus group discussions, interviews, snow-ball sampling and social network analysis (Yang, 2014). Several methods, like problem seeking, strategic needs analysis, strategic choice approach, scenario planning and design

quality indicators, have been developed to assist in the briefing stage (Nina, 2014). These methods can also be utilised when conducting stakeholder analysis.

5.3 Critical Success Factors (CSFs) for AFC projects

CSFs are typically treated as the inputs to the management system that will either directly or indirectly affect the level of project success. Such factors can be categorised into aspects including but not limited to technology, cash-flow management and quality management (Zuo et al., 2018; Chan et al., 2019). CSFs in this study represent factors that influence the performance of AFC projects. Through focus group studies in 33 cities in all WHO regions, eight major areas of age-friendly cities were identified as early as 2007, thereby eventually comprising a checklist for cities and communities worldwide (WHO, 2007a). The WHO (2015) built a framework to measure the age-friendliness of cities and communities that was comprised of equity, input, output, outcome and impact indicators. Equity, accessibility of the physical environment and inclusiveness of the social environment are treated as the most important indicators (Lui et al., 2009; Neal and Wernher, 2014; Novek and Menec, 2014; Yu et al., 2019; Chen et al., 2020).

Apart from the framework and indicators established by the WHO, which are typically applied when evaluating the age-friendliness of cities and communities, studies have also identified several factors that influence the performance of AFC

projects. Worldwide cases have indicated that political support is consistently a prerequisite. The absence of such support will eventually have repercussions on financial and human resources (Garon et al., 2014). Several studies have discussed having a common vision to enable key stakeholders to determine their directions (Garon et al., 2014; Menec et al., 2014; Arentshorst and Peine, 2018). Factors such as workload distribution, information sharing, and public levels of acceptance also play important roles in the performance of AFC projects.

According to the standards introduced by some cities in China, the indicators for measuring AFC projects can typically be categorised as follows: the physical and social environments of communities, the conditions of auxiliary facilities, the provision of services for residents and the management of human and resources (Harbin Municipal Civil Affairs Bureau, 2017; Shanghai Municipal Bureau of Quality and Technical Supervision, 2017; Jiaxing Municipal Bureau of Quality and Technical Supervision, 2019). Given the aforementioned guidelines, academic studies and Chinese standards, in the current study, the CSFs for AFC projects are divided into four categories: (1) financial factors, (2) policy factors, (3) coordinating and managing factors and (4) community environmental factors.

Table 5-3 lists detailed CSFs and the references to generate them.

Table 5-3 CSFs for AFC Projects

Code	CSF	Description	Source	Category
CSF1	The reputation and experiences of the investor	Whether the investor has a good reputation and has participated in AFC-related projects	Steels (2015); Cho and Kim (2016); Sun et al. (2017)	Financial factors
CSF2	The amount of money to be invested	How much money will the investor plan to spend on a project and the upper limit that the investor can afford	Garon et al. (2014); Glicksman et al. (2014); Menec et al. (2014); Spina and Menec (2015); Steels (2015); Buffel and Phillipson (2018)	
CSF3	The ability to develop related industries	To what extent an AFC project will facilitate the development of related industries after completion	Wu and Qu (2015); Buffel and Phillipson (2018)	
CSF4	The public's level of acceptance and powers of purchasing	To what extent will the public accept changes in their existing housing estates and their willingness to pay for services related to AFCs once needed	Hu, Xia, et al. (2015); Sun et al. (2017); Arentshorst and Peine (2018)	
CSF5	Return on investment	How long will the investor be paid back after the completion of a project	Arentshorst and Peine (2018)	
CSF6	The implementation of policies and strategies	Whether AFC-related policies and strategies are well implemented	Garon et al. (2014); Spina and Menec (2015); Steels (2015); Chan et al. (2016); Gudowsky et al. (2017); Sun et al. (2017); Buffel and Phillipson (2018); Lin et al. (2019)	Policy factors
CSF7	The coordinating system of public strategies	Whether the existing public strategies coordinate well with AFC-related ones	Spina and Menec (2015); Wu and Qu (2015)	

(Continued)

Code	CSF	Description	Source	Category
CSF8	The soundness of the promotion mechanism	Whether a sound mechanism exists to ensure that an AFC project can go smoothly	Spina and Menec (2015); Wu and Qu (2015); Harbin Municipal Civil Affairs Bureau (2017); Lin et al. (2019)	Policy factors
CSF9	Subsidies / tax reduction	Whether (or to what extent) the government will subsidise (or give tax reduction to) the AFC project investor	Cho and Kim (2016)	
CSF10	The clarity of the evaluation standards	Whether the standards are clear enough to evaluate a community's age-friendliness	Menec et al. (2014); Chan et al. (2016); Orpana et al. (2016)	
CSF11	The objectives of projects and target groups	Specific objectives that a project would achieve and the potential end users	Spina and Menec (2015); Steels (2015); Wu and Qu (2015); Lin et al. (2019)	Coordinating and managing factors
CSF12	The existence of a common vision	Whether the project team has a clear enough common goal to make the project a success	Garon et al. (2014); Liddle et al. (2014); Steels (2015); Cho and Kim (2016); Arentshorst and Peine (2018); Lin et al. (2019)	
CSF13	The clarity of the workload distribution	Whether different parties of the project team know their responsibilities	Garon et al. (2014); Menec et al. (2014); Cho and Kim (2016); Sun et al. (2017); Arentshorst and Peine (2018); Lin et al. (2019)	
CSF14	The effectiveness of communication and information sharing	Whether different parties of the project team communicate with each other and share information regularly	Garon et al. (2014); Glicksman et al. (2014); Steels (2015); Sixsmith et al. (2017); Sun et al. (2017); Arentshorst and Peine (2018)	
CSF15	Project organisation and management	Whether the organisation and managing process of a project team are effective enough	Menec et al. (2014); Sun et al. (2017); Arentshorst and Peine (2018); Lin et al. (2019)	

(Continued)

Code	CSF	Description	Source	Category
CSF16	Infrastructure conditions	Whether the infrastructure of an existing housing estate is in good condition	Lowen et al. (2015); Steels (2015); Chan et al. (2016); Cho and Kim (2016); Harbin Municipal Civil Affairs Bureau (2017); Shanghai Municipal Bureau of Quality and Technical Supervision (2017)	Community environmental factors
CSF17	The convenience of transportation	Whether an existing housing estate is easy to be accessed	Glicksman et al. (2014); Hu, Xia, et al. (2015); Lowen et al. (2015); Spina and Menec (2015); Cho and Kim (2016); Orpana et al. (2016); Harbin Municipal Civil Affairs Bureau (2017); Shanghai Municipal Bureau of Quality and Technical Supervision (2017)	
CSF18	Access to essential living service facilities	Whether the residents living in an existing housing estate have easy access to essential living service facilities (e.g., a supermarket)	Hu, Xia, et al. (2015); Lowen et al. (2015); Spina and Menec (2015); Chan et al. (2016); Cho and Kim (2016); Harbin Municipal Civil Affairs Bureau (2017); Shanghai Municipal Bureau of Quality and Technical Supervision (2017)	
CSF19	The conditions of care facilities for senior citizens	Whether a care facility for senior citizens can be reached by 15 minutes' walk starting from the existing housing estate	Lowen et al. (2015); Steels (2015); Wu and Qu (2015); Harbin Municipal Civil Affairs Bureau (2017); Shanghai Municipal Bureau of Quality and Technical Supervision (2017)	
CSF20	The conditions of medical facilities	Whether a medical facility can be reached by 15 minutes' walk starting from the existing housing estate	Lowen et al. (2015); Spina and Menec (2015); Steels (2015); Chan et al. (2016); Harbin Municipal Civil Affairs Bureau (2017); Shanghai Municipal Bureau of Quality and Technical Supervision (2017)	

(Continued)

Code	CSF	Description	Source	Category
CSF21	The layout of housing and accessibility for senior citizens	Whether the layout of an existing housing estate is accessible for senior citizens and whether it is safe to live in	Liddle et al. (2014); Chan et al. (2016); Cho and Kim (2016); Orpana et al. (2016); Harbin Municipal Civil Affairs Bureau (2017); Shanghai Municipal Bureau of Quality and Technical Supervision (2017)	Community environmental factors
CSF22	The conditions of barrier-free facilities	Whether the barrier-free facilities of an existing housing estate are in good condition	Glicksman et al. (2014); Wu and Qu (2015); Cho and Kim (2016); Orpana et al. (2016); Harbin Municipal Civil Affairs Bureau (2017); Shanghai Municipal Bureau of Quality and Technical Supervision (2017)	

5.4 SNA Results of Focus Group Discussions

Referring to the research methodology described in Chapter 4, a two-mode network of key stakeholders' concerns on CSFs was established according to the literature review and document analysis, the Delphi-panel screening session, and the links evaluated in three focus group discussions. After conducting SNA, the results can be interpreted from the perspectives of key stakeholders and the CSFs as well as their relationships.

5.4.1 From the Perspective of Key Stakeholders

Rankings of key stakeholders can be represented by three types of centrality. That is, if certain types of centrality values are the same for different key stakeholders, then the ranks of key stakeholders are calculated using the other types of centrality values. Table 5-4 shows the rankings.

Hierarchical cluster analysis is also performed to categorise key stakeholders based on their similarities. Figure 5-1 shows the tree diagrams generated using Ward's method (Milligan, 1981) through *NetMiner*. The results from the first and third round of discussions have some commonalities because S1 and S2, S3 and S7, and S4 and S5 are grouped together as similar key stakeholders, particularly based on their concerns on CSFs in the briefing stage. Three stakeholder groups are formed, although the locations of S6 are different. In the first round, the concerns of S6 are similar to those of S1 and S2. In the third round, the concerns of S4, S5 and S6 were found to be

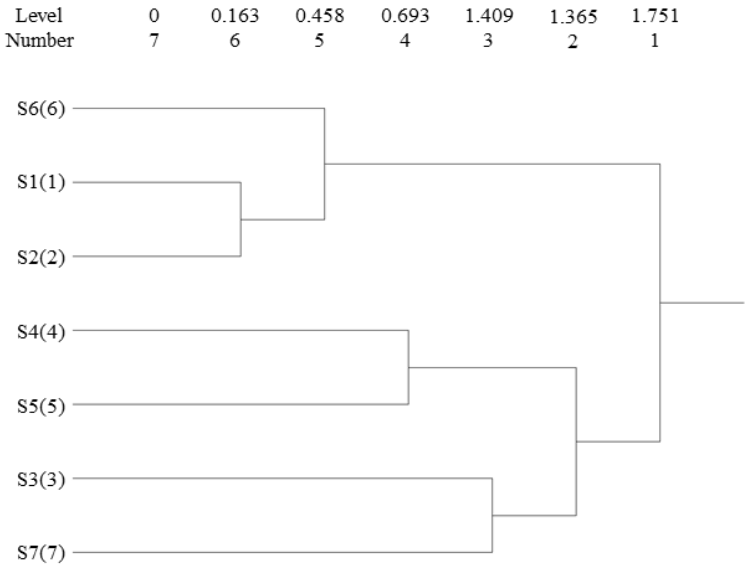
substantially similar to one another. In the second round, the results show that two larger clusters are formed: S2, S7, and S1and S4 are grouped as one cluster, whilst the remainder of key stakeholders are grouped together.

Although there are some differences among the three rounds of focus group discussions, the rankings of local governments and policymaking institutions (S3), project investors and real estate developers (S5) are considerably higher than others. These results are understandable because the central and local governments in China typically speak louder than other key stakeholders, which is also true in developed countries, including but not limited to Canada, the USA and South Korea (Greenfield et al., 2012; Chan et al., 2016; Cho and Kim, 2016). This is because the governments and policymaking institutions work to provide financial support to AFC projects and facilitate communication among various organisations (Chan and Cao, 2015).

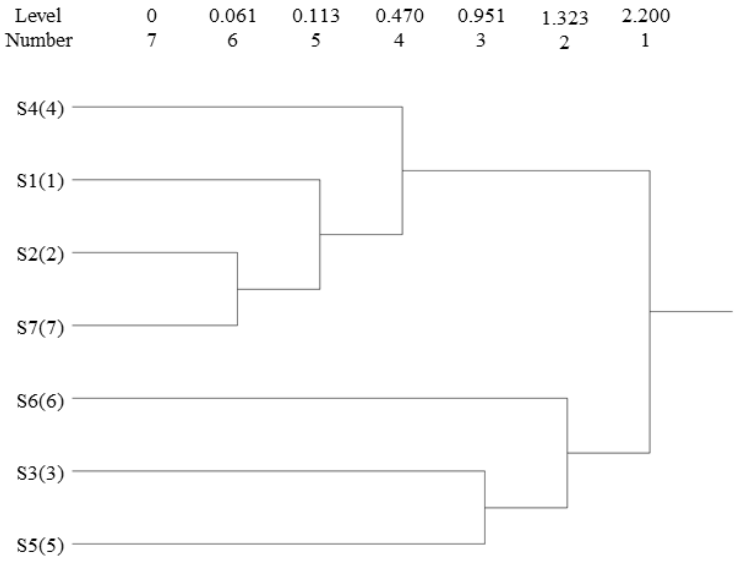
The rankings of research institutions (S4), urban planners, architects and interior designers (S6) in the first two rounds come after S3 and S5. For the third round, S6 ranks first. One possible reason for this ranking is that three of the participants chose S6 as their first or second occupation and given their previous practical experiences, their suggestions were seriously appreciated by governments and investors, thereby possibly affecting their opinions on the importance of S6.

Table 5-4 Rankings of Key Stakeholders based on Different Types of Centrality

Key Stakeholder	Round 1	Round 2	Round 3
S1: Senior citizens	6	6	6
S2: Caregivers	7	7	7
S3: Local government and policymaking institutions	1	1	2
S4: Research institutions	3	4	4
S5: Project investors and real estate developers	2	1	3
S6: Urban planners, architects and interior designers	4	3	1
S7: NGOs	5	5	5



The First-Round Focus Group Discussion



The Second-Round Focus Group Discussion

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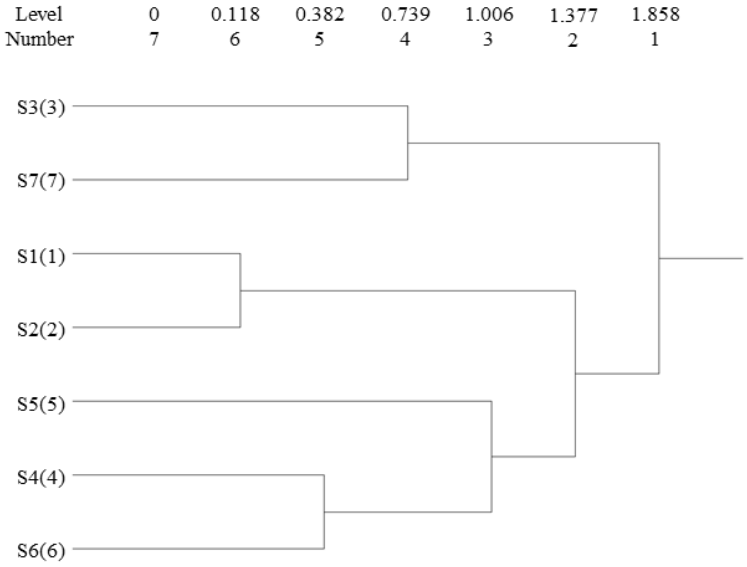


The Third-Round Focus Group Discussion

Figure 5-1 Tree Diagrams of Key Stakeholders

NGOs (S7) ranks fifth. The participants in the focus group discussions stated that although some associations, such as *Ageing Development Foundations* and community-based services groups, might provide valuable ideas for AFC projects in urban China, the impact of NGOs is typically limited. This is because only a few organisations can obtain sufficient social and financial resources or popularity, which would make a substantial difference. The majority of NGOs in mainland China are governed and directed by local governments, thereby limiting their influences.

Although senior citizens (S1) and caregivers (S2) are the actual 'end users' of AFCs, they were at the bottom two rankings. This result is due partially to the fact that numerous senior citizens in mainland China are relatively passive or do not receive

sufficient information on how to be involved in civic affairs. Therefore, they are typically optimistic that policymakers can recognise their requirements provide satisfactory results (Xiang et al., 2020). The participants considered caregivers the offspring of senior citizens or paid domestic workers rather than professional family doctors or nurses who are familiar with geriatric diseases. Thus, caregivers typically consider their parents' needs. Accordingly, S1 and S2 show the highest similarities compared with all the other key stakeholders. However, caregivers occasionally fail to understand seniors' real concerns even they exert every effort to ensure the healthy and happy lives of the latter. This outcome can explain why the caregivers ranked last.

5.4.2 From the Perspective of CSFs

The three types of centralities are also used to represent the importance of CSFs to key stakeholders. If certain types of centrality values are the same for different CSFs, then the ranks of these CSFs are calculated using the other types of centrality values. Table 5-5 shows the ranks of CSFs. Although the ranks are not precisely the same, all seven key stakeholders' concerns come to the community environmental factors because the ranks of such CSFs are above ninth. The objectives of project and target groups (CSF11), which belong to the category of coordinating and managing factors, are also considered to be a priority by key stakeholders. In particular, the participants ranked them third, sixth, and fifth in the three rounds.

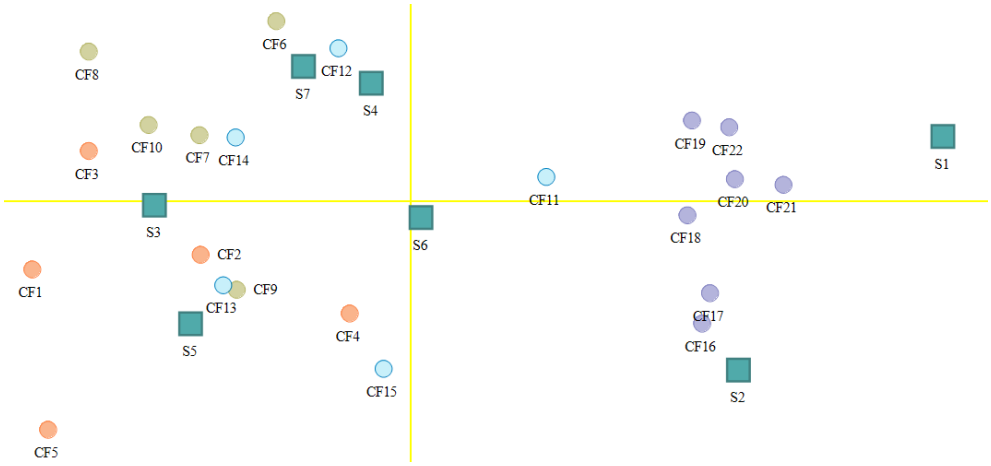
Participants from three focus group discussions reached a consensus on the implementation of policies and strategies (CSF6), which belongs to the category of policy factors, and it ranked ninth. Although some key stakeholders consider factors belonging to the financial or coordinating and managing categories to be priorities, the overall importance of the two categories (except CSF11) was relatively low, considering all key stakeholders' opinions.

Table 5-5 Rankings of CSFs based on Different Types of Centrality

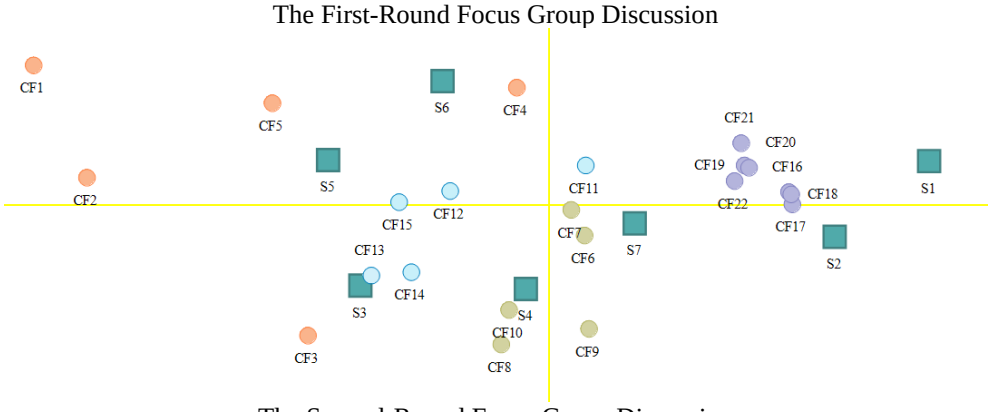
Ranking	Round 1	Round 2	Round 3	Ranking	Round 1	Round 2	Round 3
1	CSF19	CSF16	CSF22	12	CSF12	CSF10	CSF2
2	CSF16	CSF20	CSF20	13	CSF7	CSF4	CSF15
3	CSF11	CSF17	CSF21	14	CSF4	CSF8	CSF4
4	CSF20	CSF19	CSF19	15	CSF9	CSF12	CSF14
5	CSF18	CSF22	CSF11	16	CSF2	CSF15	CSF10
6	CSF22	CSF21	CSF16	17	CSF10	CSF5	CSF3
7	CSF21	CSF18	CSF17	18	CSF8	CSF13	CSF13
8	CSF17	CSF11	CSF18	19	CSF3	CSF3	CSF9
9	CSF6	CSF6	CSF6	20	CSF13	CSF14	CSF8
10	CSF14	CSF7	CSF12	21	CSF1	CSF2	CSF1
11	CSF15	CSF9	CSF7	22	CSF5	CSF1	CSF5

5.4.3 The Relationship between Key Stakeholders and CSFs

Figure 5-2 shows a macro view of the distribution of key stakeholders and their concerns; the square points in blue are key stakeholders, and the circular nodes in different colours indicate the four CSF categories. After applying the projection method to convert the evaluation matrices, the results indicated similarity of key stakeholders based on their concerns of CSFs.



The First-Round Focus Group Discussion



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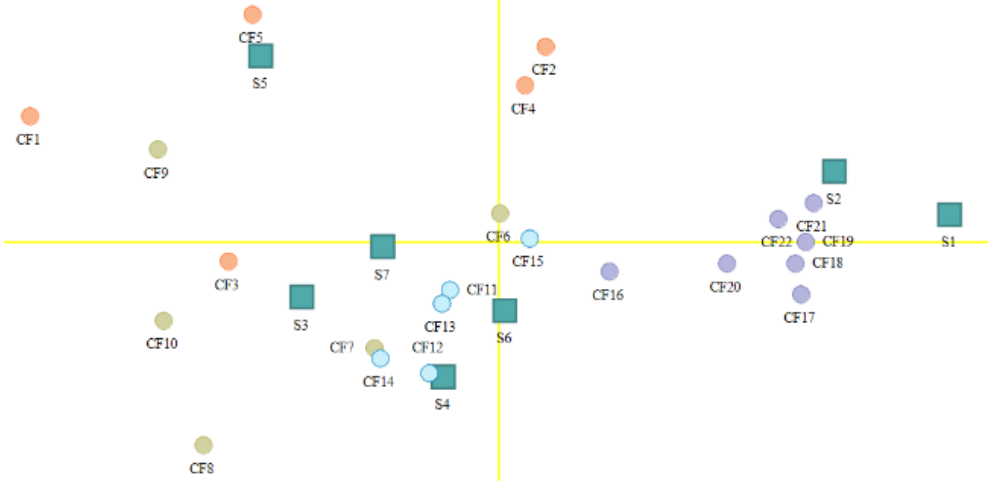

The Third-Round Focus Group Discussion

Figure 5-2 Correspondence Analysis of the Key Stakeholder-CSF Network

In the correspondence map generated through *NetMiner* using multidimensional scaling, key stakeholder points are located close together if they have similar concerns over CSFs, whereas the CSFs points are close together if similar key stakeholders

consider them as priorities. Key stakeholders and CSFs are close to each other if they have considerably strong links.

Although there are some differences, three correspondence maps generated from the evaluation matrices indicated that community environmental factors, including the infrastructure conditions (CSF16), the convenience of transportation (CSF17), access to essential living service facilities (CSF18), the conditions of care facilities for senior citizens (CSF19), the conditions of medical facilities (CSF20), the layout of housing and accessibility for senior citizens (CSF21), and the conditions of barrier-free facilities (CSF22), were the senior citizens' (S1) and the caregivers' (S2) concerns. Research institutions (S4) and NGOs (S7) had some similar concerns, such as the implementation of policies and strategies (CSF6), the coordinating system of public strategies (CSF7) and the existence of key stakeholders' common vision (CSF12).

During the focus group discussions, the priorities considered by the participants from the government (S3) were mostly related to policy factors, whilst financial factors in the briefing stage were considered important by those from investing or real estate developing companies (S5). However, this result does not mean that the government cares only about the financial factors. The participants explained that in many regions, transforming existing urban housing estates into AFCs through specific measures, such as repairing barrier-free facilities and installing elevators for ageing buildings,

were wellbeing projects that should be pursued even without a return on investment. Therefore, governments will focus considerably on policy-related issues to ensure that AFC projects can proceed. Consequently, this is the situation where conflicts typically exist between governments and investors.

Compared with S3 and S5, the consensus from the participants indicated that research institutions (S4) and urban planners, architects and interior designers (S6) cared more about coordinating and managing factors, which will affect the communication and collaboration among different key stakeholders. In addition, the participants from research institutions considered the community environmental factors to be priorities. This is because of the good conditions of infrastructure and other facilities will be beneficial to senior citizens' physical health. Urban planners, architects and interior designers (S6) thought that such factors were important because they needed to follow the design guidelines and be aware of the type of facilities required in AFCs. Such issues were also the main concerns from S1 and S2. Therefore, the similarity degree between S4, S6 and S1, S2 were relatively high.

5.5 Challenges and Implications of AFC Projects in Urban China

5.5.1 Challenges of AFC Projects under the Chinese Background

Developing age-friendly cities and communities has become a significant theme in public policy since the WHO introduced the age-friendly concept (Scharlach, 2012;

Fitzgerald and Caro, 2014; Phillipson, 2015). The CNCA proposed the 'liveable environment' concept, implemented pilot projects in several cities and communities as early as in 2009, and also suggested the creation of the 'warm family' for senior citizens as an extension of the age-friendly concept. On the basis of pilot projects, the 2012 version (implemented in 2013) of the *'Law of the People's Republic of China on Protection of the Rights and Interests of the Elderly'* introduced a new chapter titled 'liveable environment', thereby making the construction of a liveable environment a requirement from the legal perspective.

Although a breakthrough was reached in that only four years were required for the 'liveable environment' to develop from a theoretical concept to legal clauses, the construction stage of AFCs in China remains in the early phase. Many problems remain regarding the connections between the *'Law of the People's Republic of China on Protection of the Rights and Interests of the Elderly',* and other laws remain, including policies or strategies in construction. For example, no clauses in the *'Urban and Rural Planning Law of the People's Republic of China'* (revised in 2007, implemented in 2008) mention liveable communities or AFCCs. In the *'Regulation on the Construction of Barrier-Free Environments'* (introduced and implemented in 2012), the focus is on how to protect the disabled persons' rights and interests, while minimal attention has been given to seniors, particularly those with limited ADLs

levels (Hu, 2014; Wu and Qu, 2015). Therefore, AFC projects experience difficulties in urban China without clear guidelines from both legal and strategic levels. Experiences indicate that without the government and policymaking institutions (S3) working as a central authority, AFC projects will be bogged down and become ineffective (Woo and Choi, 2020).

The latest results of the national sampling survey (began in 2015, completed in 2016) on the living conditions of China's urban and rural older persons indicated that 58.7% of seniors considered their accommodations insufficiently age-friendly (Dang, 2018). Regarding community-based facilities, 59.9% and 61.6% of senior citizens expressed dissatisfaction with fitness venues and living facilities (including the supply of water, gas, heating and electricity), respectively; 62.4% were dissatisfied with signage; and 76.4% were discontented with public washrooms (Cheng and Hou, 2018). Senior citizens expect healthcare services (e.g., doctors' house visits) and daily life assistance (e.g., room cleaning) from their communities (Dang, 2018). A previous questionnaire type study conducted by the author also identified this trend (Xiang et al., 2020).

The development of AFCs is unbalanced in the urban area. The practical experiences in coastal cities or megacities, such as Qingdao, Guangzhou and Shanghai, are considerably more mature than those in inland or small and medium-sized cities. Even for particular cities, imbalanced issues of AFCs are present in newly-constructed and

formerly-built regions as well as central and marginal areas as rapid urbanisation leads to disparities in old and new urban neighbourhoods (Yu et al., 2019). For built communities, especially those completed before the 1990s, barrier-free facilities, particularly elevators inside residential buildings and ramps at entrances, are substantially needed. The lack of facilities limits senior citizens' participation in outdoor activities, causes safety problems to those with limited ADL levels and adds pressure to the governments (S3), investors (S5) and designers (S6) who will be in charge of the construction work of AFC projects. The senior citizens' sense of belonging and the influence they obtain from the traditional Chinese culture have prompted them to prefer to 'age in place' after retirement (Xiang et al., 2020). Therefore, understanding senior citizens' (S1) requirements and deciding how to renovate their current accommodations to make them age-friendly becomes one of the challenges for AFC projects in urban China. The earlier key stakeholders become aware of such conditions, the more likely it is that efficient solutions will be proposed.

Moreover, housing estate projects for seniors focus on the needs of the wealthy ageing group. That is, numerous middle- and low-income senior citizens' needs are likely to be overlooked. From the three focus group discussions, the participants from governments, real estate companies and design institutions, mentioned this phenomenon as a challenge. In particular, the participants in the second-round

discussion, who are from the same architecture and engineering design company, indicated that although the costs of apartments in these projects were relatively high for most seniors living in the urban areas, the sales conditions remained optimistic. However, wealthy seniors accounted for only a small percentage of the entire ageing group. For the remainder of senior citizens, the fact is that they become old before getting rich, which deprives them of the ability to purchase such apartments and enjoy the related care services.

5.5.2 Implications for AFC Projects in Urban China

(1) Understanding Key Stakeholders' Concerns on CSFs

Evidently, understanding key stakeholders' concerns on CSFs will balance diverse interests, values and objectives, and information resources can be expanded to support initial decision-making related to such projects (Hu, Xia, et al., 2015; King et al., 2020). A long-term goal for conducting studies on AFC projects' key stakeholders and CSFs is to build an interactive world map that includes resident-collected data, project results and other resources that can be shared by multi-stakeholders (King et al., 2020). Collaborations among stakeholders will facilitate the advancement of the WHO and other organisations' visions in exploring a true path to make cities and communities worldwide age-friendly.

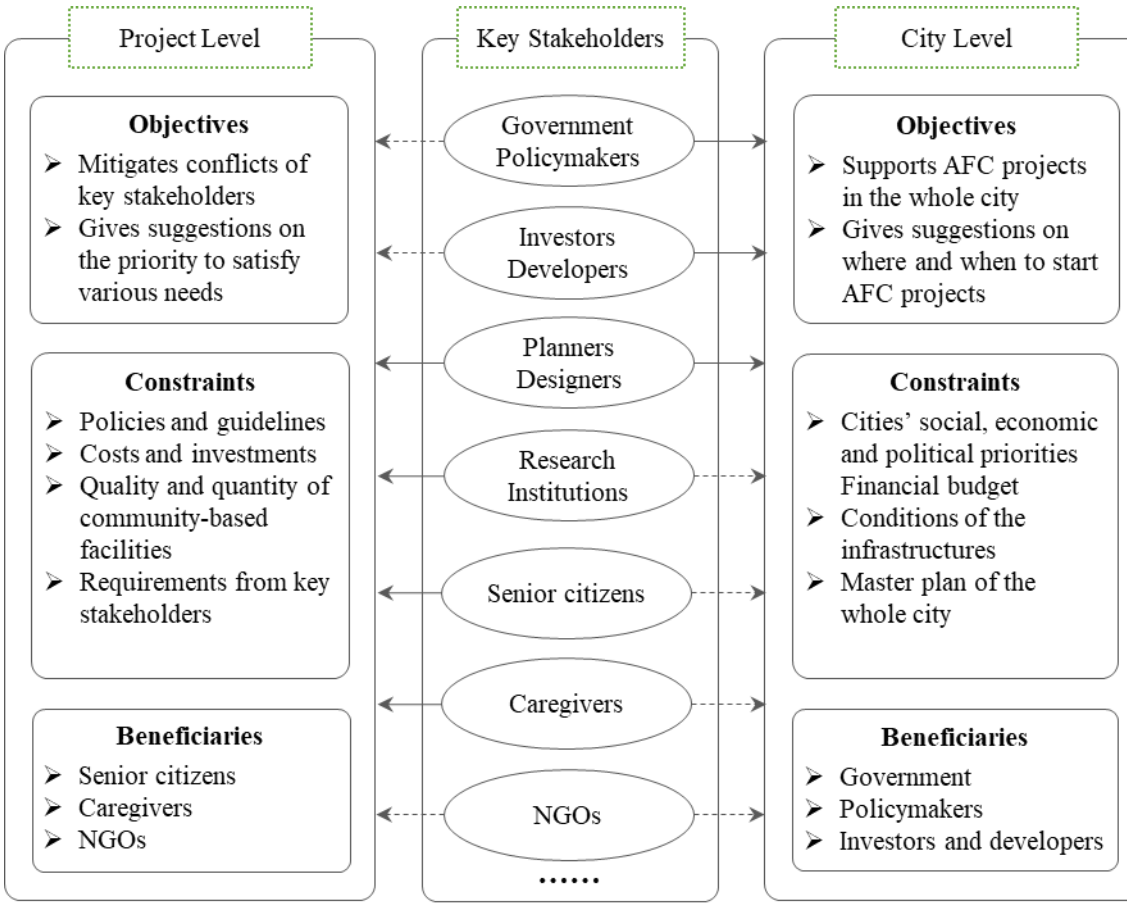

Figure 5-3 Key Stakeholders' Influences in AFC Projects

Figure 5-3 illustrates key stakeholders' influences in AFC projects at the project and city levels, specifically based on the SNA results and participants' perceptions generated from the three rounds of focus group discussions. The solid arrows represent direct influences, and the dotted arrows represent relatively indirect impacts.

Urban China's current patterns of promoting AFC projects can be divided into four main types: (1) allocating elderly-care facilities in newly-constructed communities, (2) developing *Continuing Care Retirement Communities* for senior citizens, (3) constructing or renovating community-based elderly care facilities in the built regions

and (4) redesigning spare buildings, including but not limited to factories, office buildings, and guesthouses, into elderly care facilities. Based on practical experience, the third type is widely accepted to transform existing urban housing estates into AFCs in China. It is because that the community-based facility can not only satisfy senior citizens' needs for 'ageing in place', but are typically small-scale and require minimal investment. Therefore, the pattern is easy to be replicated (Zhou and Li, 2015). Currently, more private capital group incline to invest in AFC projects are exploring opportunities related to constructing or renovating community-based elderly care facilities. The participants in the focus group discussions also considered this pattern to be ideal for promoting AFC projects.

(2) A Framework for the briefing stage of AFC Projects

Figure 5-4 depicts the main steps in the briefing stage, with key stakeholders involved and the CSFs that should be considered. The first task to be completed when transforming existing urban housing estates to AFCs is accessing senior citizens' (S1) and their caregivers' (S2) needs in terms of the social and physical environment of communities (CSF16~CSF22). This is because they are the 'end users' of AFCs and can provide developers (S5) and designers (S6) with first-hand information on which component of their current accommodations and communities should be renovated. Moreover, engaging S1 and S2 in the briefing stage will enhance senior citizens' and

their caregivers' perceptions of autonomy, empowerment and collective agency because they will witness how such ideas lead to tangible improvements to their living environments (Buffel, 2019; King et al., 2019; 2020). This finding is also consistent with the WHO's objectives of pursuing the *Global Age-Friendly Cities* project with a focus on seniors' 'lived' experiences (WHO, 2019).

After obtaining users' opinions, senior citizens' needs should be clarified based on their different ADL levels and income conditions at the briefing stage. As indicated by the participants from the three focus group discussions, the objectives of projects and target groups (CSF11) are prioritised by key stakeholders in addition to the community environmental factors. By completing the classification, the standards for service provision, facility operation and construction management can be easily set at an early period of the project. This undertaking will be beneficial to S1 and S2, as well as S5 and S6. On the basis of the clear objectives of AFC projects, governments and policymaking institutions (S3) can offer preferential policies (CSF5~CSF10) to S5, thereby ensuring effective resource use (CSF1~CSF4).

During the briefing stage, key stakeholders should clarify their responsibilities (CSF11~CSF15). Based on the rankings of key stakeholders and clustering results drawn from the three rounds of focus group discussions, S3 and S5 are suitable key stakeholders to facilitate meetings and discussions among the different stakeholders.

S3 is suggested to consider incorporating policy incentives, such as urban renewal ones, with AFC projects at the same time, in order to achieve broader goals with one action. Research institutions (S4) and NGOs (S7), as comparatively neutral components, are suggested to be the consultants to facilitate the conduct of prophase investigations with S1 and S2. They could provide valuable suggestions to S6 because they are professional and familiar with expressing user requirements. Through comprehensive research on user needs (Step 1), the classification of the project objectives and target groups (Step 2), together with the assignment of key stakeholders' responsibilities (Step 3), the strategic plan for AFC projects will mainly be formed by S5 and S6 as the last step of the briefing stage. In this way, potential conflicts between key stakeholders can be mitigated or even prevented, and the management process of AFC projects is likely to be improved.

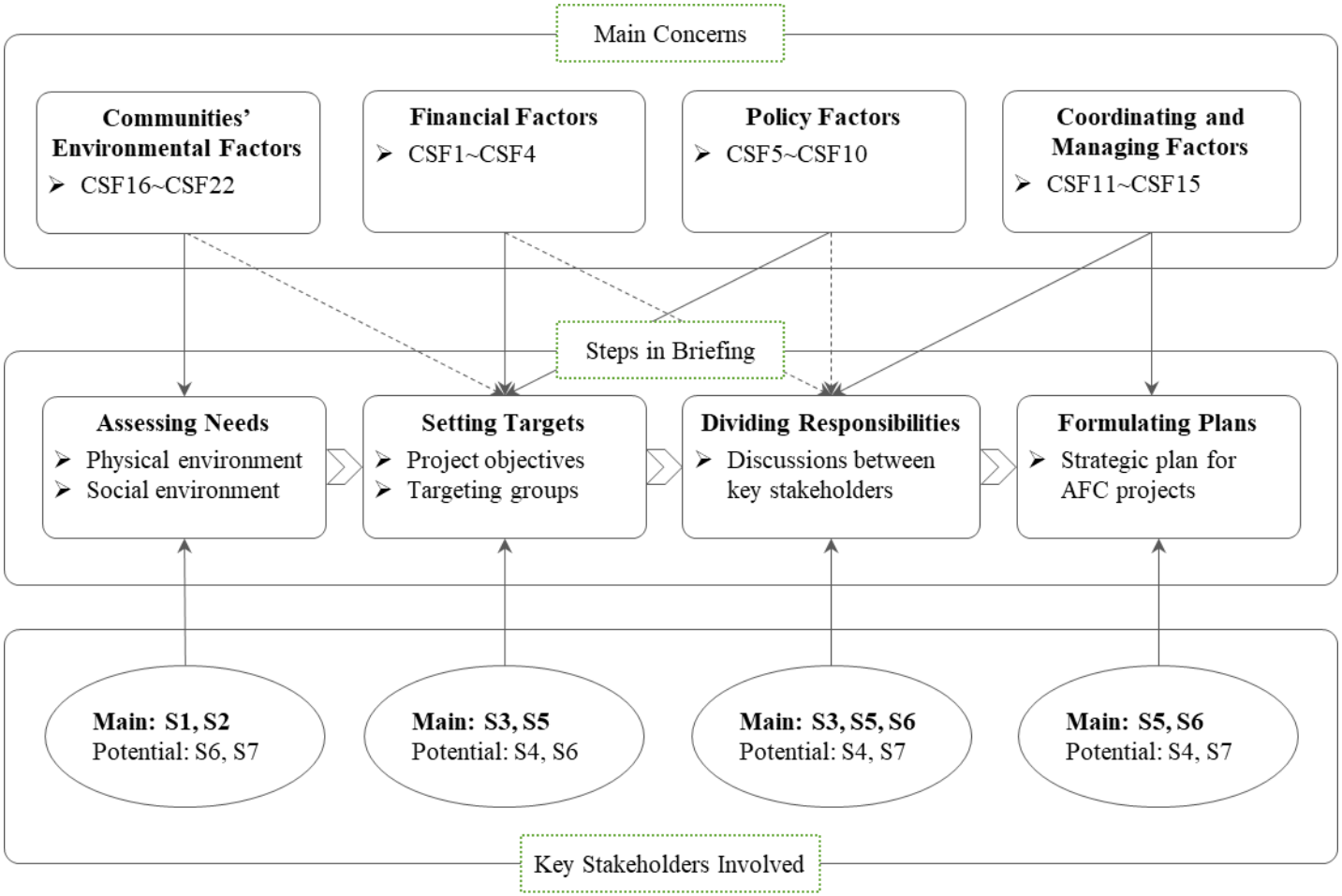

Figure 5-4 A Framework for the Briefing Stage of AFC Projects

5.6 Summary

Efficient collaborations of many parties are required for AFC projects in the urban settings of China, and efforts should be made to address a variety of issues arising from the working period. The results generated from the focus group discussions indicate that during the briefing stage, local governments and policymaking institutions (S3), together with project investors (S5) obtain comparatively higher rankings, whilst senior citizens (S1) and caregivers (S2) appear to rank last among all seven key stakeholders. With regard to the CSFs, the community environmental factors receive the most attention from key stakeholders. The main challenges of AFC projects in urban China are the lack of connection between legal clauses and construction strategies, imbalanced development situations in different regions and insufficient barrier-free and elderly-care facilities in the communities. A framework for the briefing stage of AFC projects in urban China, which includes the main concerns and key stakeholders involved in each step, is proposed in this chapter.

CHAPTER 6 A MULTI-AGENT PLATFORM TO SUPPORT THE BRIEFING STAGE OF AGE-FRIENDLY COMMUNITY PROJECTS IN URBAN CHINA

6.1 Introduction

This chapter first follows the framework of applying MASs in construction management area, which is proposed in Chapter 3, and carries out an agent-based simulation regarding how consensus is built among key stakeholders based on a real case. Then strategies to mitigate key stakeholders' conflicts are explored for AFC projects in urban China based on the simulation results. After that, the components and variables of a multi-agent platform (MAP) to support the briefing stage of AFC projects are summarised. At last, the conceptual design of the MAP is presented.

6.2 Simulating Key Stakeholders' Consensus Building to Mitigate Conflicts

6.2.1 Background and Configuration

An agent-based model is built based on a real case in Shanghai to simulate the consensus building process of key stakeholders and to explore strategies to mitigate conflicts. Shanghai is one of the four municipalities that directly under the central government of China and had no less than 24.28 million residents by the end of 2019 (National Bureau of Statistics of China, 2020). Despite the policies enacted to cap its fast population growth, Shanghai remains attractive due to high levels of job

opportunities, the quality of its infrastructure, as well as its education and health care services (The Economist Intelligence Unit, 2018). Projections made by *The Economist Intelligence Unit* (2018, 2019) indicate that the population gain of Shanghai would be more than 2 million and 22 per cent of the total residents will be over 65 years old by 2030 (Figure 6-1 and Figure 6-2). Shanghai faces great challenges due to its ageing population, and it has followed the guidelines for constructing AFCs since 2013. Experiences of AFC projects in Shanghai provide examples for other cities to follow.

Figure 6-1 Metropolitan Population Gain in 2016~30 (The Economist Intelligence Unit, 2018)

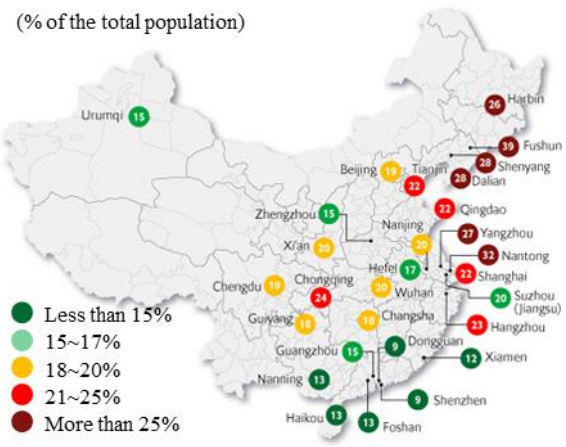

Figure 6-2 Population over 65 Years of Age till 2030 (The Economist Intelligence Unit, 2019)

The target case study community was built in 1994, and most of the original residents transitioned from middle-age to old age after 2010. Elderly care facilities were in great need, and the investor wanted to renovate the original community centre into a small-scale care facility for the seniors. However, for a majority of residents, the facility was treated as a 'nursing home', and they thought it was unlucky to live nearby because there is a traditional impression that nursing homes are uncomfortable

and unsightly. Moreover, some residents believed that ambulances might require access on occasion, which would make them anxious and depressed. In summary, the residents acknowledged the value of the elderly care facility; however, they did not want it to be built near their community, regardless of the plan to change their original community centre into such a facility (Vanke Weekly, 2015). The objections from residents made the project difficult to commence; therefore, strategies to deal with the problem were in great need.

To build the agent-based model, assumptions are made on the basis of several opinion dynamic models. One such model is proposed by Hegselmann and Krause (2002), which indicated that one person would neither simply share nor strictly disregard the opinion of any other, but would consider others' ideas and weigh the impacts during the process of forming an opinion. Taking an average of opinions and forming an actual one, the dynamic process of forming opinions is achieved in discrete periods of time. Another opinion dynamic model is the majority rule model proposed by Galam (2002), which assumes that each individual has either a supportive or an opposing opinion initially and that random discussion groups are formed thereafter. Each individual could interact and exchange ideas within the group. As a result of the communication that follows, the majority opinion of the discussion group is selected by all the members. Another model combines the plurality rule and can be considered

as an extension of the majority rule model, which allows each agent to have more than two equivalent states of opinions, and a freezing phenomenon occurs as a result (Chen and Redner, 2005).

In this study, the situation of the target community is real while the social network and opinions among residents are idealised. Considering the total number of households, ageing rate and structure of the owners' committee in the target community, three types of agents were used in the simulation: (1) A_m: Households that include a member from the owners' committee, (2) A_s: Households that include at least one member aged 65 years or over, and (3) A_o: Oher households. Since the target community includes 4,193 households, the numbers of A_m, A_s and A_o were set as 11, 1260 and 2922, respectively. The implemented model can be treated as a multi-state opinion model in which agents' initial attitudes were clarified as approval, neutral or disapproval, with +1, 0, or -1 to imply the three types, respectively. The weights of approval and disapproval were considered to be greater than that of neutral attitudes (Le Pira et al., 2016). During the consensus building process, agents interacted with others and changed their initial attitudes based on their neighbours' opinions with a probability related to various influences. Therefore, the attitudes of certain agents changed on the basis of their neighbours' opinions rather than a specific time frame. In addition, agents' attitudes did not change directly from approval (+1) to

disapproval (-1), and vice versa. Instead, they passed through a neutral (0) status that indicated an undecided phase. The simulation results thus depict the differences among the initial approval rates and the connections among the residents, which affect residents' final opinions.

6.2.2 Properties of Agents and the Simulation Performed

Apart from holding attitudes of approval, neutral or disapproval, each agent was initialised with two properties: (1) A social impact factor, which is an integer number in the range [0,10] and reflects the social importance of an agent. For A_m, A_s and A_o, the number was set as 10, 6, and 2, respectively. (2) An 'influenceability' factor, which is a random real number in the range [0,1], indicates the possibility that an agent directly changes its opinion to the opposite side without passing through a neutral stance. In this study, if the value of this parameter is no less than 0.5, then an agent would have the possibility of directly changing its opinion to the opposite. Otherwise, it will pass through the neutral status before changing the initial attitude.

The agent-based model built in this study was run in *NetLogo 6.1.1*, a multi-agent programmable modelling environment that can be applied to explore interactions between agents and the phenomenon emerges as a result of such interactions (Wilensky and Rand, 2015; Lu et al., 2016). Figure 6-3 illustrates the interface of the simulation model. The simulation performed can be described by two main stages,

which establish the initial condition (t=0) and the opinion dynamics (t>0).

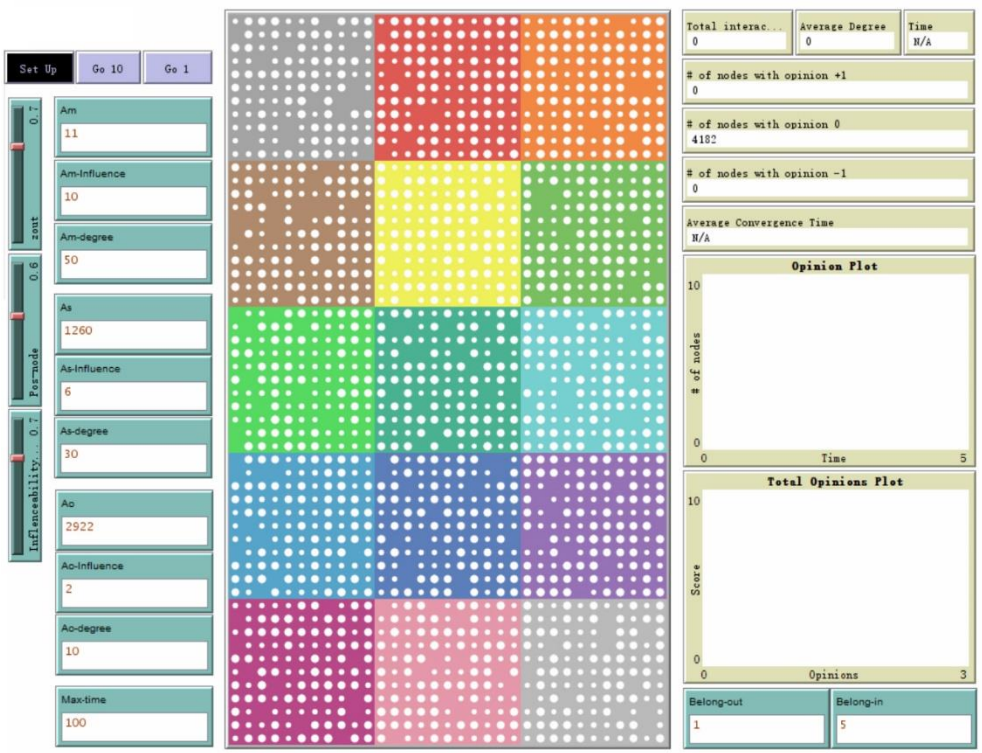

Figure 6-3 Interface of the Simulation Model

(1) Setup of the Initial Condition (t = 0)

The masterplan indicates that the target community consists of 15 subregions. Therefore, the 4,193 households (agents) were divided into 15 groups, and each group was composed of approximately 280 agents. The connections among the agents in each group formed the social network. The number of connections that an agent can make depends on the different influence factors: for A_m, A_s and A_o, the total connections they could make were set as 50, 30 and 10, respectively, on average. Compared with the agents inside the group, those outside the group had lower impacts on a certain agent. Such assumptions are reasonable as members from the owners'

committee are considered to be the representatives of other residents, and they are able to connect with more residents. In addition, the seniors in the study spend most of their time in the community and may become more familiar with others than the rest of the community's residents. Finally, an opinion was assigned to all the agents when *t=0*, and this simulation mainly explores the initial approval rate, which shows how many agents that are in favour of the renovation proposal, would be needed to influence the consensus building process.

The details of the agents' properties are summarised in Table 6-1.

Table 6-1 Properties of Agents for the Simulation

Variable	Number of Agents	Average Connections	Social Impact Factor
A_m	11	50	10
A_s	1260	30	6
A_o	2922	10	2

(2) The Opinion Dynamics (t > 0)

Since agents interact with others and change the initial attitudes based on their neighbours' opinions, assuming that $x_i(t)$ is the opinion of agent *i* at time *t*, the opinion of that agent at time $t+1$ will be a function of both $x_i(t)$ and $v_i(t)$, where $v_i(t)$ is the vector filled with the weighted opinions $n(t)$ of all the neighbours with which agent *i* has connections (Le Pira et al., 2016). The routines of the opinion dynamics model are shown in Figure 6-4.

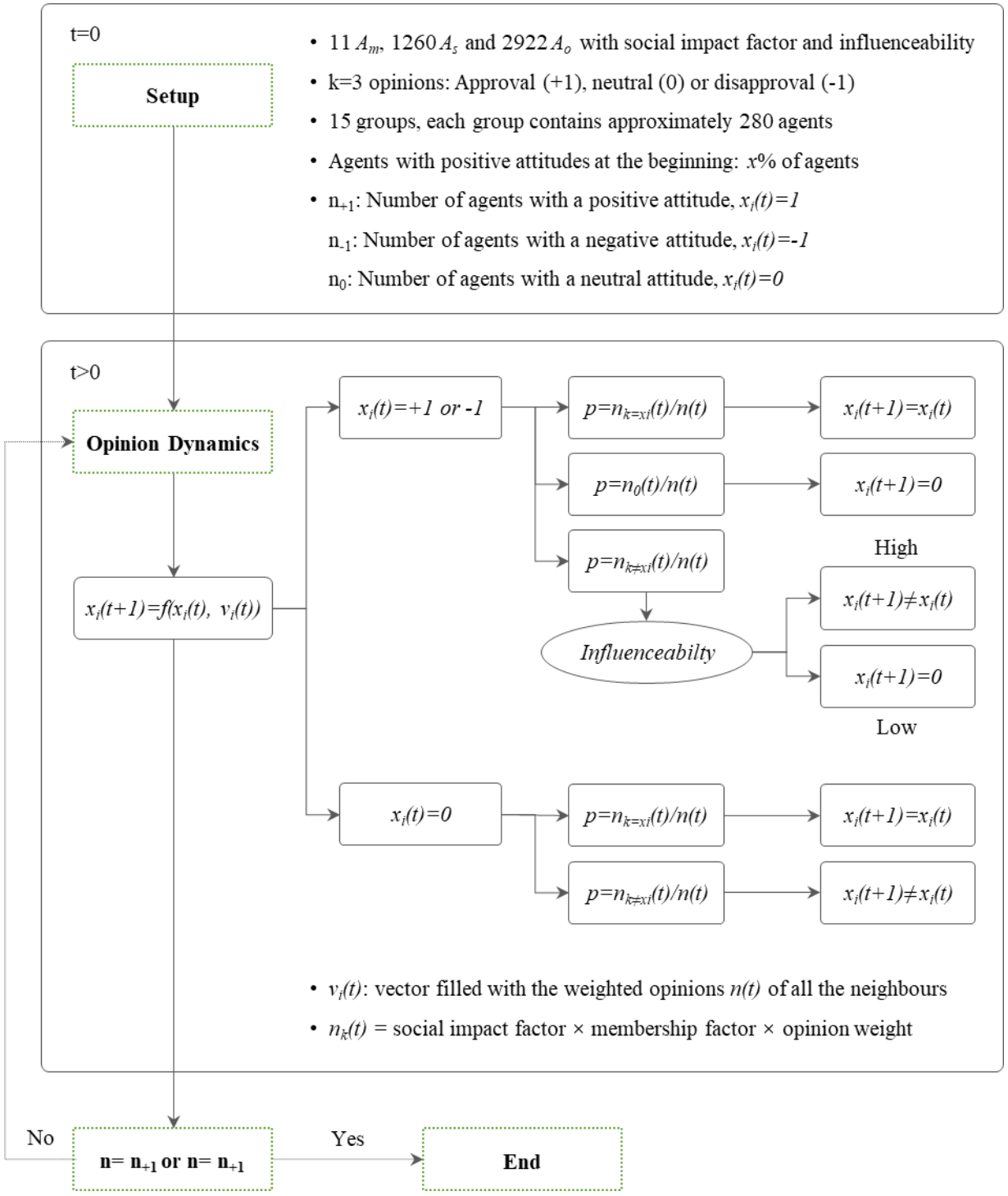

Figure 6-4 Routines of the Simulation Model (Le Pira et al., 2016)

The dynamics of opinions can be represented through the line chart with three curves, with each one representing the change of an opinion over time. Figure 6-5 illustrates a single event such that, after struggling among three opinions, all the agents reached a

consensus by the end of the simulation. Figure 6-6 depicts ten events with the same parameters, and by the end of the given events, the histogram shows that the predominant opinion is either a consensus or a dissent. Both figures indicate that the neutral opinion is only a transitional phase.

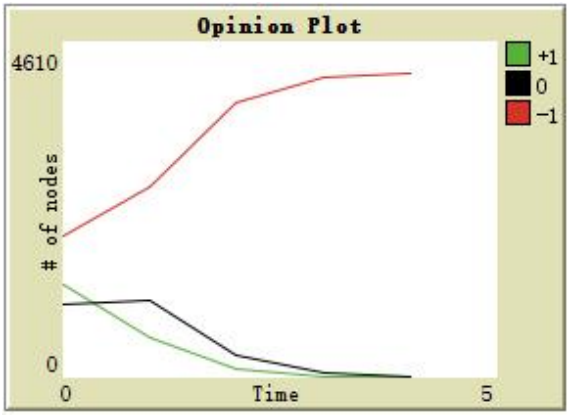

Figure 6-5 Opinion Plot for a Single Event

Figure 6-6 Opinion Distributions for 10 Events

Since the simulation conducted in this study focuses on how different initial approval rates and the connections among agents affect residents' final opinions, two main model parameters can be modified: (1) The initial approval rate, which is the percentage of agents who are in favour of the proposal at the beginning of the simulation. (2) The outside connection rate, which is the percentage of connections an agent makes outside the group. Both parameters can be changed from 0 to 100%.

It was assumed that when the investor proposed a plan to renovate the community centre into a small-scale care facility for seniors, the initial approval rate was 20%, considering the residents' concerns mentioned in 6.2.1. The outside connection rate

was also set as 20% since it was realistic that one might have more connections with those who live nearby. For A_m, A_s and A_o. the connections made outside the group were 10, 6 and 2, respectively. During the simulation, the two parameters were changed accordingly to explore how they would affect the agents' final opinions.

6.2.3 Simulation Results and Analysis

A series of simulations were conducted, and attention was paid to the events in which all the agents held the same opinion in the end. In particular, complete consensus (all opinions equal to +1) or dissent (all opinions equal to -1) is more meaningful than neutral opinions (all opinions equal to 0).

To clarify the final opinions, a unique parameter *C* (Convergence achieved rate) was calculated by Equation 1 to imply the result when convergence was achieved (Le Pira et al., 2016). E_{+1} and E_{-1} indicate the times when the simulation processes ended with complete consensus or dissent, respectively, while *E* stands for the total number of events. The simulation ends with all the opinions equal to 0 is not taken into consideration as all residents holding a neutral opinion would not be helpful for investors in implementing their proposal in practice. The value of *C* ranges from -1 to 1, where -1 indicates that all the events ended with complete dissent, while +1 means that such events ended with complete consensus.

$$C = \frac{E_{+1} - E_{-1}}{E}$$ Equation 1

During the simulation process, a limitation on time (t≤100) was set to exclude cases when it took too long for the simulation process to reach convergence. It should be noted that *C* does not stand for any step during the simulation process; it only refers to the final status when consensus or dissent is reached. Table 6-2 illustrates the simulation results when *E=10* with parameter *C* defined above. The outputs of each simulation result listed in Table 6-2 are shown in Appendix II: Outputs of the Agent-Based Simulation.

Table 6-2 Simulation Results Indicated by Parameter *C* (t≤100)

Convergence Achieved Rate (*C*)		**Outside Connection Rate (%)**						
		20	**30**	**40**	**50**	**60**	**70**	**80**
Initial Approval Rate (%)	**20**	-0.8	-0.4	-0.8	-0.8	-0.6	-0.8	-0.8
	30	-0.1	-0.2	-0.3	-0.7	-0.2*	-0.1	0*
	40	0.3	0.2	0.7	0.2	0*	+1*	-0.2*
	50	0.8	0.8	0.9	0.9	+1*	+1*	0.8*
	60	+1*	+1*	+1*	+1*	+1*	+1*	+1*
	70	+1*	+1*	+1*	+1*	+1*	+1*	+1*

* All ten events ended with either consensus or dissent.

Table 6-2 shows that both the initial positive rate and the outside connection rate influence parameter *C*. To ensure convergence for each event, the initial positive rate should be no less than 50%, with an outside connection rate that is no less than 60%. In addition, when the initial positive rate was lower than 40%, even in cases of

convergence achieved by the end of the simulation, the residents were more likely to have attitudes of disapproval towards the investor's proposal. The outside connection rate can be considered to be the 'weak tie' proposed by Granovetter (1977), which is helpful to facilitate information exchange from different groups. The simulation results indicate that when the outside connection rate was no less than 60%, the convergence was more likely to be reached for all events. With such a value equals to 40% or more, it is likely that even the initial positive rate was lower than 50%, the residents would have complete approval attitudes regarding the investor's proposal when the simulation process ended.

Table 6-3 Simulation Results Indicated by Parameter *T* (t≤100)

Average Convergence Time		**Outside Connection Rate (%)**						
		20	**30**	**40**	**50**	**60**	**70**	**80**
Initial Approval Rate (%)	**20**	3.125	3.667	3.125	3.125	4.000	3.750	4.375
	30	4.200	3.750	3.600	4.286	4.900*	4.667	5.500*
	40	4.286	3.500	3.571	3.750	7.200*	4.400*	5.400*
	50	3.125	3.500	4.556	4.444	4.300*	4.400*	5.700*
	60	3.200*	3.100*	3.300*	3.900*	3.900*	3.600*	3.900*
	70	3.000*	3.000*	3.000*	3.200*	3.400*	3.100*	3.100*

* All ten events ended with either consensus or dissent.

The average convergence time (*T*) listed in Table 6-3 is another parameter to which the author paid attention. Since the simulation was conducted with ten events as a group, if a certain event in the group did not reach convergence before t=100, then it would be neglected when calculating *T*. It should also be noted that, in this study, *T*

stands for the number of rounds of information exchange that occur before the convergence is reached, rather than an exact duration.

According to the simulation conducted, when all ten events in a group ended with convergence, *T* appeared to be at least 3.000, with no less than 70% of the agents holding a positive opinion at t=0. When the initial approval rate was 40%, and the outside connection rate was 60%, *T* peaked at 7.200, meaning that more than seven rounds of information exchange were needed on average to achieve convergence. Although a higher initial approval rate and a lower outsider connection rate may reduce *T*, three-to-five rounds of information exchange are still required before a complete consensus or dissent is obtained.

6.2.4 Implications for Key Stakeholders at the Briefing Stage

The simulation results obtained from modelling residents' opinion dynamics provide investors with implications for facilitating the renovation proposal, mainly by improving both the initial approval rate and the outside connection rate.

The initial approval rate is highly correlated to residents' concerns, as discussed in 6.2.1. As for the target case study community, the facility that the investors intended to promote was an *Embedded Retirement Facility* (ERF), which gradually emerged from 2014 in mainland China as a response to the *Embedded Retirement Pattern* (Hu,

Wang, et al., 2015). Unlike the traditional ‘nursing home’ considered by most residents, an ERF is defined as a small-scale, multifunctional community-based care facility with a total construction floor area of no more than 800 m^2, a service radius of no more than 450 m and a capacity of no more than 45 beds for senior citizens. An ERF can offer day respite services, long-term residence or both. ERFs not only assist senior citizens in their daily lives but also help them maintain good health conditions through programs such as providing canteens, organising social and recreational activities and providing regular health examinations (Zhang and Zhao, 2017; Xiang et al., 2020). Therefore, investors should communicate with residents and let them know the properties of the facility so as to eliminate residents’ prejudice and alleviate their concerns about the renovating proposal. In addition, investors should also consider leaving areas to be used by younger residents. Although a community-based care facility for seniors is needed, younger residents still have the right to use the community centre. It would be unfair to the broader community to renovate the whole centre without considering their needs.

Increasing the outside connection rate means to facilitate interactions among residents who live in different regions of the community. One potential method is organising activities for the whole community to provide opportunities for residents to exchange information and ideas. It may also be helpful if the investors convince and receive

support from owners' committee members or seniors, as they have more opportunities to interact with others and obtain more social impact than other residents.

Practical experiences of the case confirmed the strategies proposed based on the simulation results: The investors, designers and other construction group members first visited a large number of residents, and they explained the meaning of renovating the community centre to obtain support. Changes were then made regarding the initial proposal, and indoor spaces were retained for other residents to conduct physical activities (Vanke Weekly, 2015). The effective communication and collaboration among key stakeholders at the briefing stage not only ensured the success of the project but also provided ideas to be followed by similar projects.

6.3 The Design of a MAP for the Briefing Stage of AFC Projects

The agent-based simulation conducted in 6.2 provides strategies for the construction group to promote the renovating plan of a community centre by modelling the opinion dynamics of the end users, which is part of the MAP for the briefing stage of AFC projects in urban China. In this study, the proposed MAP mainly assists in dealing with conflicts among key stakeholders caused by their different concerns on CSFs. The components, variables and structure of the MAP are described as follows.

6.3.1 Components of the MAP

In general, an ABM is formed by three sets of elements: (1) the agents, (2) the interactions among the agents, and (3) the interactions between agents and the environment (Wilensky and Rand, 2015). The term ‘agent’ in this study refers to a cluster of key stakeholders that engaged in AFC projects. Key stakeholders are generally clarified as being either internal and external: internal groups are defined as those who directly participate in the decision-making process while external groups are treated as those with no decision-making control but with varying degrees of influence on the performance of certain projects (Hu, Xia, et al., 2015). Based on Chapter 5, seven key stakeholders are identified for AFC projects in urban China, which are the senior citizens (S1), caregivers (S2), government and policymaking institutions (S3), research institutions (S4), project investors and real estate developers (S5), urban planners, architects and interior designers (S6), as well as NGOs (S7).

The widely accepted and implementable approach to promoting AFC projects in urban China is constructing or renovating community-based elderly care facilities in the built regions, during which process three clusters formed by five key stakeholders play important roles (Zhou and Li, 2015; Li and Zheng, 2019; Xiang et al., 2020): (1) the end user cluster includes S1 and S2, whose needs should be clarified based on different ADL levels and income conditions. Residents who live in the same

community with S1 and S2 also belong to this cluster. (2) S3 is the supervision cluster and comprises those whose applications for the incentive policies will influence real estate developers' and investors' choices regarding the promotion of AFC projects. And (3) the construction cluster includes S5 and S6, those who are responsible for the quality of the construction work. The above clusters are defined as three agents in the design of the MAP, specifically, the end-user agent, the supervision agent, and the construction agent.

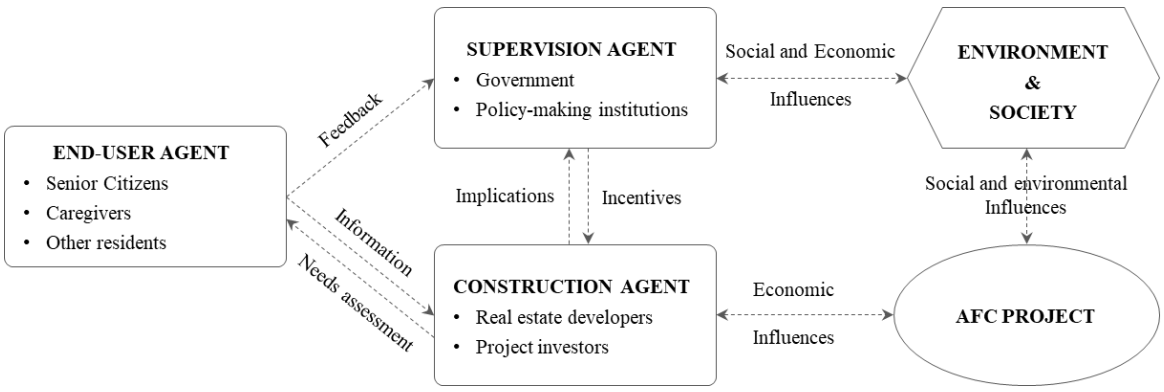

Figure 6-7 Relationships among Agents in AFC Projects

Figure 6-7 illustrates relationships among the three agents during the briefing stage of AFC projects. The supervision agent provides the construction agent with policy incentives such as public financial support and tax and land use benefits, and identifies implications for adjusting policies and regulations (Li and Zheng, 2019). The construction agent is responsible for determining the condition of the built communities, assessing the needs of the end-user agent, and carrying out the strategic and implemental plans. The end-user agent is able to provide the construction agent

with first-hand information pertaining to the components of their current accommodations and communities that should be adjusted, such as whether current service provisions can assist in the daily lives, or whether barrier-free facilities are adequate for participation in physical activities. In addition, the extent to which the other residents can accept the renovation or construction of community-based elderly care facilities in the built regions will influence the relative difficulty in promoting AFC projects (Hu, 2014). Feedback from the end user agent is often collected by the supervision agent, particularly after the completion of AFC projects, to evaluate the quality of the work completed by the construction agent.

Figure 6-7 also depicts the influences of the agents on AFC projects, the environment and society. The construction agent typically invests in AFC projects with subsidies from the supervision agent with plans for remuneration scheduled several years after completion. The potential contributions of AFC projects can be clarified at both the environmental and social levels with the aim of promoting AFCs to ensure that communities are inclusive and equitable places where even the most vulnerable people can live in (WHO, 2018). Although difficulties usually occur in promoting AFC projects due to the burdens of resources (Buffel et al., 2014), the government and policy-making institutions as the supervision agent gain social and economic benefits from promoting an age-friendly society in the long term.

6.3.2 Variables of the MAP

Several variables (Table 6-4) are considered in designing a MAP for AFC projects either by constructing or renovating community-based elderly care facilities in the built urban regions. For a specific project, the variables may be classified into more detailed categories with additional ones. Figure 6-8 depicts the interactions of agents and illustrates the influences among variables.

Table 6-4 Definitions of General Variables

Type	Variable	Definition	Category
End-user	L_u	The ADL level	Time dependent
	A_u	The acceptance level of community-based elderly care facilities	Time and action dependent
Supervision	I_g	The incentive provided by the government to the construction group	Action dependent
	U_g	The utility of incentive policy	Time and action dependent
Construction group	E_c	The efforts made for AFC projects	Action dependent
	C_c	The cost of AFC projects	Time and action dependent
	B_c	The benefits from AFC projects	Time and action dependent
Environmental variable	S_e	The site area of an AFC (m^2)	Static
	I_e	One-thousand indicators	Static
	P_e	Price of building materials	Time dependent
	F_e	Conditions of facilities in the current community	Time and action dependent
Intermediate variable	E_i	Economic benefit from AFC projects	Time and action dependent
	E_{ni}	Environmental benefit from AFC projects	Time and action dependent
	S_i	Social benefit from AFC projects	Time and action dependent

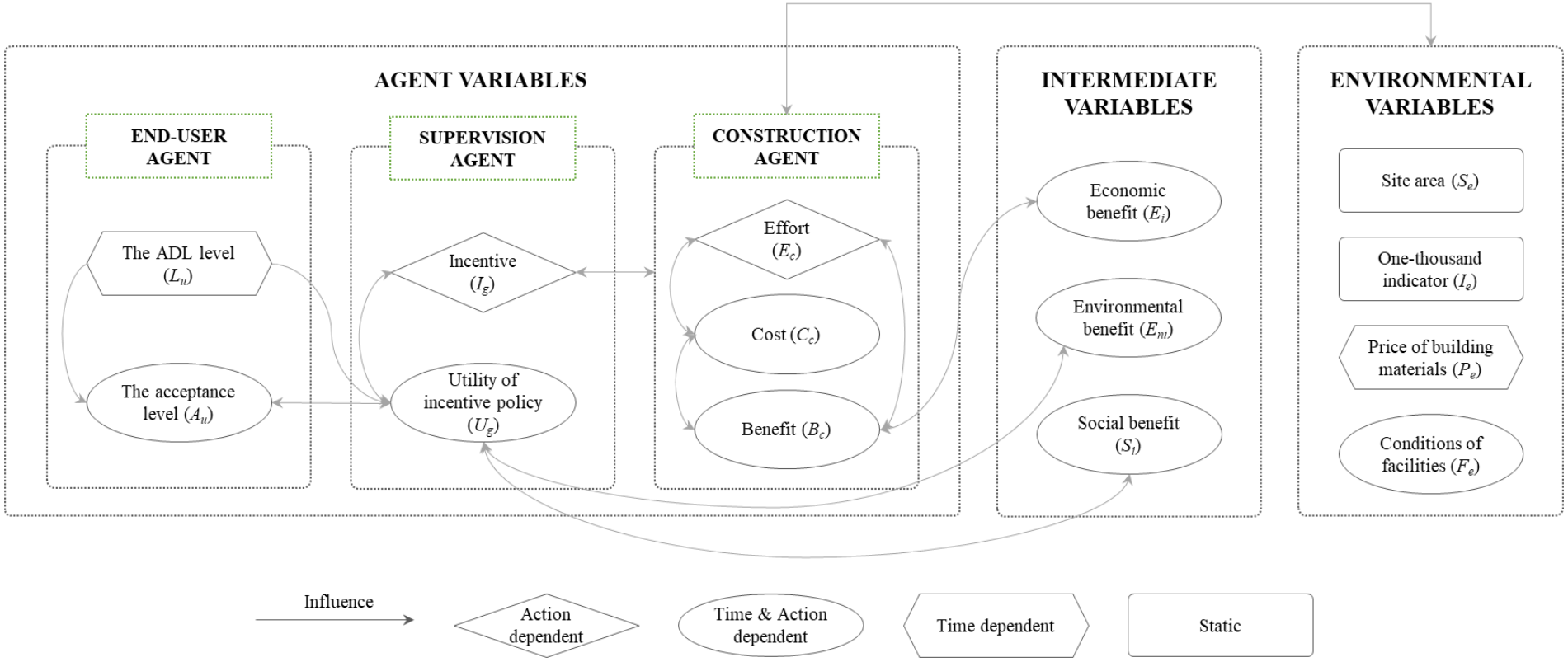

Figure 6-8 Variables and Interactions among Agents

(1) End-User Variables

The ADL level of the end user L_u involves the fundamental skills required to manage basic physical needs that compromise eating, walking, bathing, dressing, toileting, transferring and continence. Considering the level of care, L_u ranges from 0 to 4 in round numbers, with 0 representing that the end-user can complete daily-life activities independently, while 4 indicates that the end-user requires total assistance (Mlinac and Feng, 2016; Assisted Living Today, 2020). L_u is a time-dependent variable, meaning that the older the end-user is, the larger the value may be.

The acceptance level of community-based elderly care facilities A_u indicates the extent to which the end-user will accept the changes in the built community, such as renovating a community centre to a community-based elderly care facility. The value of A_u ranges from 0 to 1, where 0 indicates that end-users are totally opposed to, while 1 means that end-users strongly agree with making such changes. The simulation conducted in 6.2 clarifies A_u into two parts, which are the initial approval rate and the three opinions (approval, neutral, disapproval) held by each resident.

(2) Government Variables

The incentive of a government to aid the construction group I_g represents the policy of preferential treatment given by the supervision agent to the construction agent. Such a

treatment is beneficial to construction groups but constitutes a cost to the government. Typically, the more I_g that is received, the more B_c construction groups will obtain. However, I_g will also influence U_g because the higher the I_g, the more that will be paid by the government.

The utility of incentive policy U_g represents the overall satisfaction obtained by the government from giving incentives to construction groups. The main benefit for the government is to ensure an equitable and inclusive society in which people may live; thereby releasing the financial burden of care services, especially for seniors. However, a high I_g is likely to decrease U_g, since the government must strike a balance between welfare support and its financial burden.

(3) Construction Group Variables

E_c refers to the efforts of construction groups for AFC projects, which include but are not limited to time, money and human resources. The value of E_c is from 0 to 1, with 0 indicating no efforts were made by the construction group, while 1 means that the group made the best effort. E_c has a positive connection with A_u: The simulation results obtained from 6.2 indicate that if the investor communicates effectively with the residents and makes reasonable changes to increase the initial approval rate, the consensus from the residents will be achieved more easily, and the project will therefore be more smoothly promoted. E_c will also influence the cost of AFC projects

and the benefits that the construction team will receive after the completion.

The cost of AFC projects C_c is related to the efforts made by construction groups and will influence the benefits they obtain. Typically, the more efforts exerted, the more cost, and the longer time it may take to be paid back.

The benefits from AFC projects B_c include both social and economic benefits; the former is related to the reputation of the construction group, while the latter is related to the cost and income for AFC projects. The value of B_c will also have an effect on U_g in the long term.

(4) Environmental Variables

The site area S_e and one-thousand indicators I_e are the static variables during the construction process. One-thousand indicators are set for planners and designers as both guidelines and limitations to ensure that the AFC will cater to senior citizens' needs, such as including functional spaces and the services that should be provided in elderly care facilities, the distance from the community to important locations, such as hospitals and supermarkets.

The price of building materials P_e and the conditions of facilities in the current community F_e are important variables as they influence the cost of the whole project directly and, therefore, will influence the costs and benefits to the construction group.

(5) Intermediate Variables

The economic, social and environmental benefits from AFC projects E_i, S_i and E_{ni} are the intermediate variables in the MAP. E_i is the intermediate variable for the construction group to calculate the benefits ($B_c=E_i+I_g-C_c$) while S_i and E_{ni} are intermediate variables mainly for the government to consider when making decisions regarding the utility of incentive policies.

6.3.3 The Structure of the MAP

The MAP designed in this study is supposed to help the government and the construction group make better decisions during the briefing stage of AFC projects. The platform aims to support users at both the project and the policy levels: For the project level, suggestions are mainly given regarding how to deal with conflicts among key stakeholders. While at the policy level, suggestions are supposed to be made for the government regarding the extent to which incentives should be given to the construction group.

The structure of the MAP is developed based on the *Proactive Construction Management System* proposed by Li et al. (2015). Figure 6-9 illustrates the three tiers of this platform: (1) the presentation tier, (2) the processing tier, and (3) the data tier. The presentation tier is designed for users to choose agents and variables, which is discussed in 6.3.1 and 6.3.2 and to set specific scenarios for simulation. The

processing layer is where the MAP runs within the modelling environment. The data tier includes general indicators and algorithms that would not change on a case-by-case basis. After the simulation process, the results regarding specific scenarios are displayed in the presentation tier for users to interpret and obtain strategies to promote AFC projects in urban China. Figure 6-10 depicts the potential interface of the MAP where the user is logged in as a project investor.

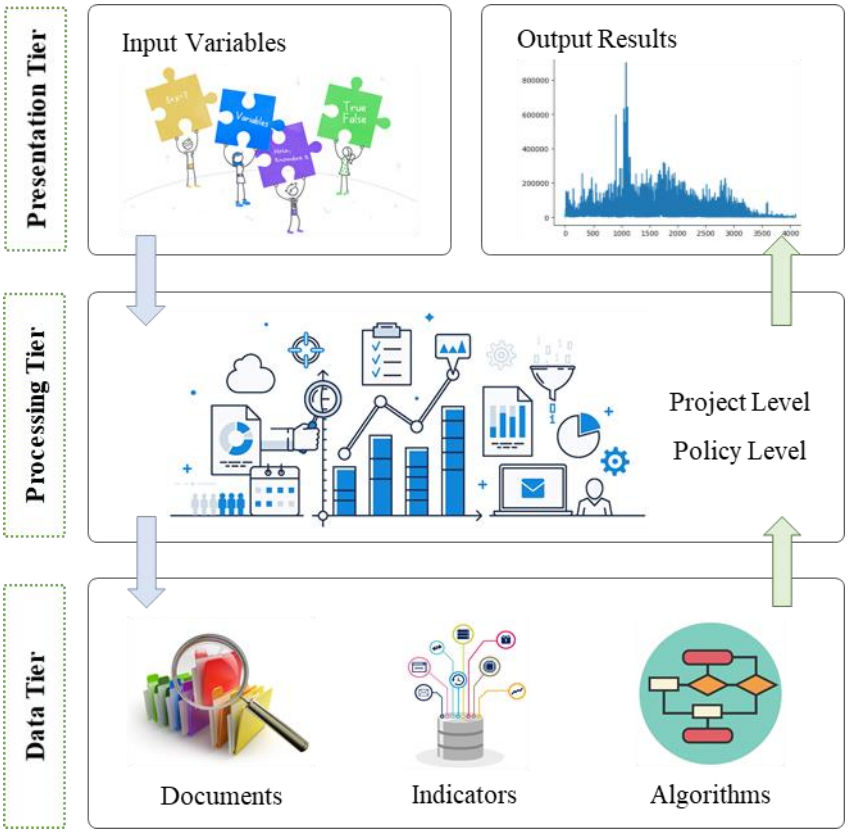

Figure 6-9 Three Ties of the MAP

Figure 6-10 Interface of the MAP

6.4 Summary

The briefing stage is treated as an indispensable part for AFC projects in urban China. During this stage, many aspects should be taken into consideration by different key stakeholders before the strategic plan can be established. The agent-based simulation of key stakeholders' consensus building process conducted based on a real case provides the foundation for designing a MAP. The proposed MAP would not only facilitate the understanding of key stakeholders' relationships but also inform strategies to deal with conflicts among key stakeholders during the briefing stage for AFC projects. The components and variables of the three-tier structured MAP are described in this chapter, and the potential interface of the MAP is illustrated.

CHAPTER 7 CONCLUSIONS

7.1 Introduction

As the last section of the thesis, this chapter first summarises the key research findings to examine the fulfilment of the research objectives. Then, this chapter concludes by presenting both theoretical and practical. Finally, limitations and future directions are discussed.

7.2 Research Findings and Fulfilment of the Research Objectives

Referring to the three specific objectives mentioned in 1.3, the first is accomplished by conducting a literature review on studies related to AFCs and carrying out Delphi panel screenings. The foundation, hot topics and critical areas of AFCs studies are first summarised to understand current research progress in Chapter 2. Then key stakeholders engaged in AFC projects, their roles to play, and CSFs for AFC projects are identified. Related descriptions can be referred to in Chapter 4 and 5.

Research questions related to the first objective are also answered in Chapter 4 and 5. Key stakeholders engaged in AFC projects in urban China are similar to other countries worldwide, but their roles can be different. CSFs for AFC projects can be divided into several categories, including financial factors, policy factors, coordinating factors, and conditions of communities. Policy factors, together with

conditions of communities, may affect financial investment. Coordinating factors may contribute to a smooth briefing stage of AFC projects.

To achieve the second research objective, three rounds of focus group discussions are conducted to generate stakeholders' concerns on CSFs during the briefing stage. A two-mode social network is applied to analyse the evaluation matrices obtained from the focus group discussions. The results of the SNA indicate that local governments and policymaking institutions, together with project investors, are given high priority in the key stakeholders' group, whilst senior citizens and caregivers appear to rank last. Thus, Key stakeholders can be divided into the end-user group, the construction group and the supervision group, based on their different priorities on CSFs during the briefing stage of AFC projects. With regard to the CSFs, community environmental factors receive the most attention from key stakeholders. Based on the SNA results, a framework for the briefing stage in AFC projects is proposed. The stage starts with a needs assessments of the physical and social environment considering senior citizens' and caregivers' opinions, as they are the 'end-users' of AFCs and are able to provide developers and designers with first-hand information on which components of their current accommodations and communities should be renovated. Then, a clarification of senior citizens' needs based on the ADL levels and income conditions, together with a specification of key stakeholders' responsibilities, is presented. After the

above-mentioned steps, the strategic plan for AFC projects can be formulated. Chapter 5 shows the related research findings, which also replies to the second research question raised in 1.4.

An agent-based model is developed based on the framework proposed in Chapter 3, to simulate key stakeholders' consensus building process in the context of a real case. According to the simulation results, the consensus building among key stakeholders can be influenced by many factors, including but not limited to end-users' acceptance level of the AFC projects, efforts made by the construction group, and the incentive provided by the government to the construction group. Strategies to build consensus among key stakeholders are proposed and validated, which can serve as references for similar cases in other cities. On the basis of the agent-based simulation, the general components and variables that should be included in a MAP for the briefing stage of AFC projects are summarised. Then, a three-tiered MAP is designed with the potential interface illustrated. Chapter 6 reports the above-mentioned accomplishment regarding the last research objective and responds to the third research question.

7.3 Contributions of the Research

7.3.1 Theoretical Values

This study makes original contributions to knowledge of AFCs and the briefing stage during construction projects in several aspects.

First, a roadmap for AFC research is developed, which not only determines the characteristics of AFCs, worldwide experiences in promoting AFC projects, and the evaluation of communities' age-friendliness as critical research areas but also illustrates the broad picture regarding the objective of making communities age-friendly. The roadmap will serve as a useful reference for scholars to enhance their understanding of the current research and to guide future research on AFCs. The roadmap will also provide helpful guidance for service providers, practitioners, and governments to develop fit policies.

Second, key stakeholders' relationships are identified according to their concerns on CSFs during the briefing stage of AFC projects. Although a majority of previous studies have focused on either a key stakeholder or CSF perspective, limited studies have been conducted analysing and considering both aspects as part of a whole. The importance of fostering effective collaborations by carrying out analyses of key stakeholders during the briefing stage is also emphasised because the sooner a project's key stakeholders are aware of each other's concerns, the more likely it is that efficient solutions will be formed.

Moreover, a three-tiered MAP is proposed to support consensus building among key stakeholders during the briefing stage of AFC projects. With the results obtained from modelling key stakeholders' consensus building process, the importance of improving

the initial approval rate to facilitate investors' original renovation proposal of a community centre is indicated. In particular, the strength of a 'weak tie' is emphasised as it can facilitate the information exchange among key stakeholders.

7.3.2 Practical Implications

The findings of this study can support practitioners of AFC projects in several aspects. First, practitioners can follow the framework developed in this study to explore the relationship among key stakeholders and their concerns on CSFs. The main challenges of AFC projects in urban China identified in this study are the lack of connection between legal clauses and construction strategies, the imbalanced development situations in different regions, and the insufficient barrier-free and elderly-care facilities in communities. Such challenges imply that key stakeholders must make changes. For example, central and local governments should focus more on making effective connections between legal clauses and construction strategies, as well as provide policy and financial support to address imbalanced developing issues in different regions. Project investors and designers should address issues regarding insufficient barrier-free and elderly care facilities, which would be their major tasks when transforming existing urban housing estates into AFCs.

Moreover, practitioners can apply the MAP presented in this study to both understand the participating key stakeholders better and to explore strategies for mitigating

conflicts. For example, the simulation results in 6.2.3 suggest that investors communicate with residents, eliminate their prejudice and alleviate their concerns about the renovation proposal. It is further suggested that the designers of the simulated case make changes to the original plan and leave a space for residents other than senior citizens. The strategies proposed based on the simulation results were mostly applied by the investors to tackle the dissent arising from the residents. Finally, the project went smoothly and became a success.

7.4 Research Limitations and Future Directions

Despite the research findings and contributions listed above, this study has some limitations that may serve as starting points for future studies.

First, the data collected in the key stakeholder analysis section is limited. As no participants from NGOs were able to join the focus group discussions, their concerns were generated from the other key stakeholders' past experiences of working with or communicating with them, thereby possibly leading to some misunderstandings. The caregiver who participated in this study was not a professional one and focused considerably on seniors' daily lives. By contrast, professional caregivers focus more on healthcare issues. Diverse voices are needed in future studies.

Second, this study is mainly a theoretical one. The results generated from this study

are general. Key stakeholders' attributes and CSFs can change when AFC projects are promoted in different cities. For example, cold weather in the northeast part of China will bring more challenges to the construction group than in the southern part. A limited financial budget in medium- or small-sized cities will also hinder the construction process of AFC projects. To determine the specific issues faced by key stakeholders and the measures that they can apply to deal with conflicts, further studies may start by bringing key stakeholders who have completed an AFC project together to participate in focus group discussions. Case studies should also be conducted to validate the proposed framework of the briefing stage for AFC projects.

Third, the MAP designed in this study mainly addresses conflicts among key stakeholders and provides potential suggestions on the priority order regarding satisfaction of stakeholders' needs. Although the agent-based simulation conducted in this study is based on a real case, the simulation process addresses only conflicts between the project investor and residents; other key stakeholders and constraints are not included. Future research may begin by including other variables to generate a more thorough MAP and extend the platform to include not only key stakeholder relationship issues but support AFC projects considering the whole city. Apart from the key stakeholder relationship, constraints under such circumstance comprise upper-level issues such as social, economic and political priorities, financial budget,

and the city's master plan. Comments collected from potential users would also be helpful to improve the future MAP.

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APPENDICES

Appendix I: The Document Used in Focus Group Discussions for SNA

As the three rounds of focus group discussions mentioned in Chapter 5 were conducted in mainland China. Therefore, the document used was the Chinese version of Appendix I. In case of any discrepancy, the Chinese version prevails.

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

A Survey of Key Stakeholders and their Relationships at the Briefing Stage of Age-Friendly Community Projects

(Focus Group Discussion, Round ___)

Time: _____

Location: _____

Total Participants: _____

No.: _____

DEPARTMENT OF BUILDING & REAL ESTATE
建築及房地產學系
INTERNATIONAL • COLLABORATIVE • CONSTRUCTION

1 BASIC INFORMATION

1.1 Personal Information

Occupation: _____

Working Experiences: _____ / Years

1.2 The Process of Focus Group Discussion

- Reading and analysing the document (completed by participants individually)
- Adding, deleting and ranking the listed indicators (completed by participants individually)
- Summarising and announcing results (completed by the host)
- Discussing the differences (completed by participants together under the guidance of the host)
- Reaching a consensus (completed by participants together under the guidance of the host)

1.3 The Content for Discussion

The purpose of this survey is to **identify the key stakeholders in age-friendly community (AFC) projects** and **discuss their concerns on critical success factors (CSFs) at the briefing stage**.

To be more specific, **AFCs** include eight major areas: outdoor spaces and buildings, transportation, housing, social participation, respect and social inclusion, civic participation and employment, communication and information, community support and health services. AFCs should support senior citizens ageing actively and empower them in daily life considering their requirements for **participation, health, security**

and independence. The **briefing** stage is the first step in the design and construction process, and it establishes the broad scope and purpose of key parameters including the project's overall budget.

This focus group meeting is supposed to last **2.5 to 3 hours**. The answers you give only indicate your understandings about the key stakeholders, CSFs and relationships. The collected data will be kept confidential, and your personal information will not be disclosed.

Should you have any concerns, please feel free to contact Ms. Liqun XIANG, PhD candidate from department of Building and Real Estate, the Hong Kong Polytechnic University, at emma.lq.xiang@ You may also contact *The Hong Kong Polytechnic University Research Committee* regarding ethical issues.

Thank you again for your kind help and your valuable contribution to this research!

2 IDENTIFICATION OF KEY STAKEHOLDERS

Table 1 displays and explains seven key stakeholders in AFC projects according to the literature review, the semi-structure interview and the Delphi panel screening results. You may specify (or delete) items based on your understandings of them.

Please select no more than two key stakeholders and fill in the codes from (your adjusted version of) Table 1 that best describe your roles if you participate in the briefing stage of an AFC project. You may fill in *Not Applicable* for the second choice if there is no need to choose.

First Choice: _____

Second Choice: _____

Table 1 Descriptions of Key Stakeholders

Code	Key Stakeholder	Description	Experience
S1	Senior citizens	People aged 60 years old or over who live in their own home in the community and rely on both family care and community-based services	_____ years
S2	Caregivers	Professionals (such as doctors or nurses) who are familiar with geriatric diseases and knows how to take care of seniors with limited ADL levels	
		Non-professionals (such as relatives or friends of senior citizens) who should typically be at least 18 years old but below 60 years old. He or she should also spend at least three months annually living with senior relatives in the same city	
S3	Local government and policymaking institutions	Members from organisations such as the national and/or local *Committee on Ageing*, the *Home Affairs Bureau*, or the *Planning and Natural Resources Bureau*	
S4	Research institutions	These institutions involve researchers who engage in real estate, affordable housing, construction management, gerontology, geriatrics, geriatric nursing, sociology and other related studies	
S5	Project investors and real estate developers	Institutions or groups of people who provide financial support for AFC projects, companies or groups of people who are responsible for real estate development work	
S6	Urban planners, architects and interior designers	These professionals form companies or groups that are responsible for the planning and designing work	
S7	NGOs	Members of the *Ageing Development Foundation*, the *Retired Staff Committee*, the *Volunteer Association*, or other community-based groups	
S_	Others: _____	Please specify	

3 IDENTIFICATION OF CRITICAL SUCCESS FACTORS

Table 2 displays 22 CSFs for AFC projects according to the literature review, the semi-structure interview and the Delphi panel screening results. You may specify (or delete) items based on your understandings of them.

Table 2 Classifications of Critical Success Factors

Code	CSF	Description	Category
CSF1	The reputation and experiences of the investor	Whether the investor has a good reputation and has participated in AFC-related projects	Financial factors
CSF2	The amount of money to be invested	How much money will the investor plan to spend on a project and the upper limit that the investor can afford	
CSF3	The ability to develop related industries	To what extent an AFC project will facilitate the development of related industries after completion	
CSF4	The public's level of acceptance and powers of purchasing	To what extent will the public accept changes in their existing housing estates and their willingness to pay for services related to AFCs once needed	
CSF5	Return on investment	How long will the investor be paid back after the completion of a project	
CSF6	The implementation of policies and strategies	Whether AFC-related policies and strategies are well implemented	Policy factors
CSF7	The coordinating system of public strategies	Whether the existing public strategies coordinate well with AFC-related ones	
CSF8	The soundness of the promotion mechanism	Whether a sound mechanism exists to ensure that an AFC project can go smoothly	

(Continued)

Code	CSF	Description	Category
CSF9	Subsidies / tax reduction	Whether (or to what extent) the government will subsidise (or give tax reduction to) the AFC project investor	Policy factors
CSF10	The clarity of the evaluation standards	Whether the standards are clear enough to evaluate a community's age-friendliness	
CSF11	The objectives of projects and target groups	Specific objectives that a project would achieve and the potential end users	Coordinating and managing factors
CSF12	The clarity of the common vision	Whether the project team has a clear enough common goal to make the project a success	
CSF13	The clarity of the workload distribution	Whether different parties of the project team know their responsibilities	
CSF14	The effectiveness of communication and information sharing	Whether different parties of the project team communicate with each other and share information regularly	
CSF15	Project organisation and management	Whether the organisation and managing process of a project team are effective enough	
CSF16	Infrastructure conditions	Whether the infrastructure of an existing housing estate is in good condition	Community environmental factors
CSF17	The convenience of transportation	Whether an existing housing estate is easy to be accessed	
CSF18	Access to essential living service facilities	Whether the residents living in an existing housing estate have easy access to essential living service facilities (e.g., a supermarket)	
CSF19	The conditions of care facilities for senior citizens	Whether a care facility for senior citizens can be reached by 15 minutes' walk starting from the existing housing estate	
CSF20	The conditions of medical facilities	Whether a medical facility can be reached by 15 minutes' walk starting from the existing housing estate	

(Continued)

Code	CSF	Description	Category
CSF21	The layout of housing and accessibility for senior citizens	Whether the layout of an existing housing estate is accessible for senior citizens and whether it is safe to live in	Community environmental factors
CSF22	The conditions of barrier-free facilities	Whether the barrier-free facilities of an existing housing estate are in good condition	
CSF__	Others: _____		Please specify

4 THE RELATIONSHIP AMONG KEY STAKEHOLDERS

According to your **experiences in practical projects** and your **personal knowledge**, please rate the key stakeholders' concerns on CSFs at the briefing stage of AFC projects in urban China. That is, describe your understanding about which key stakeholder will take certain CSFs into consideration and to what extent.

Please fill in the blanks of Table 3 with the number of 1 to 5 to indicate different key stakeholders' concerns on CSFs, where meanings of the numbers are:

1 = key stakeholders 'will not consider CSFs in most cases'

2 = key stakeholders 'will not consider CSFs in some specific cases'

3 = key stakeholders 'hold a neutral attitude towards CSFs'

4 = key stakeholders 'will consider CSFs in some specific cases' and

5 = key stakeholders 'will consider CSFs in most cases'

For example, if you put '5' for the 'senior citizens' (S1) concern on 'The investor' (CSF1), it means that, based on your understanding, S1 will consider CSF1 in most cases of AFC projects.

Please fill in the items that you added in the second and third parts of Table 3, if any, and rate them.

Table 3 Key Stakeholders' Concerns on CSFs

Key stakeholder / **CSF**	Senior citizens	Care givers	Local government and policymaking institutions	Research institutions	Project investors and real estate developers	Urban planners, architects and interior designers	NGOs	Others: _____
Financial factors								
The reputation and experiences of the investor								
The amount of money to be invested								
The ability to develop related industries								
The public's level of acceptance and powers of purchasing								
Return on investment								
Others: _____								
Policy factors								
The implementation of policies and strategies								

(Continued)

Key stakeholder / **CSF**	Senior citizens	Care givers	Local government and policymaking institutions	Research institutions	Project investors and real estate developers	Urban planners, architects and interior designers	NGOs	Others: _____
Policy factors								
The coordinating system of public strategies								
The soundness of the promotion mechanism								
Subsidies / tax reduction								
The clarity of the evaluation standards								
Others: _____								
Coordinating and managing factors								
The objectives of projects and target groups								
The clarity of the common vision								
The clarity of the workload distribution								

(Continued)

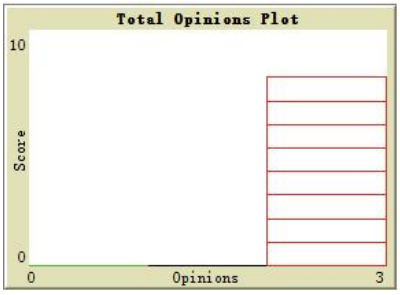
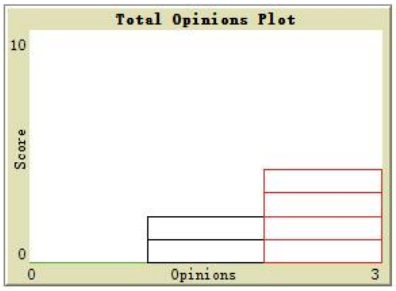
Key stakeholder / **CSF**	Senior citizens	Care givers	Local government and policymaking institutions	Research institutions	Project investors and real estate developers	Urban planners, architects and interior designers	NGOs	Others: _____
Coordinating and managing factors								
The effectiveness of communication and information sharing								
Project organisation and management								
Others: _____								
Community environmental factors								
Infrastructure conditions								
The convenience of transportation								
Access to essential living service facilities								
The conditions of care facilities for senior citizens								

(Continued)

Key stakeholders / **CSFs**	Senior citizens	Care givers	Local government and policymaking institutions	Research institutions	Project investors and real estate developers	Urban planners, architects and interior designers	NGOs	Others: _____
Community environmental factors								
The conditions of medical facilities								
The layout of housing and accessibility for senior citizens								
The conditions of barrier-free facilities								
Others: _____								
Other critical factors that do not belong to the above four categories								
Others: _____								
Others: _____								
Others: _____								

Appendix II: Outputs of the Agent-Based Simulation

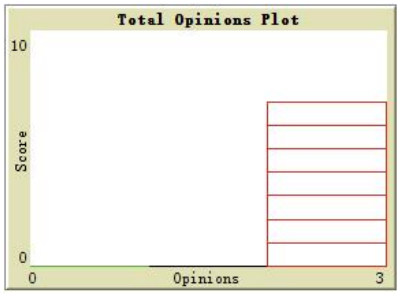
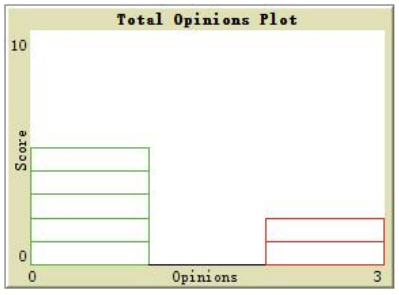
Table 1 Parameters and Output Figures of the Agent-Based Simulation

Output Figure	Parameters for Simulation	Times of convergence
	Initial approval rate: 20% Outside connection rare: 20%	Approval (+1): 0 Neutral (0): 0 Disapproval (-1): 8
	Initial approval rate: 20% Outside connection rare: 30%	Approval (+1): 0 Neutral (0): 2 Disapproval (-1): 4
	Initial approval rate: 20% Outside connection rare: 40%	Approval (+1): 0 Neutral (0): 0 Disapproval (-1): 8
	Initial approval rate: 20% Outside connection rare: 50%	Approval (+1): 0 Neutral (0): 0 Disapproval (-1): 8
	Initial approval rate: 20% Outside connection rare: 60%	Approval (+1): 0 Neutral (0): 2 Disapproval (-1): 6

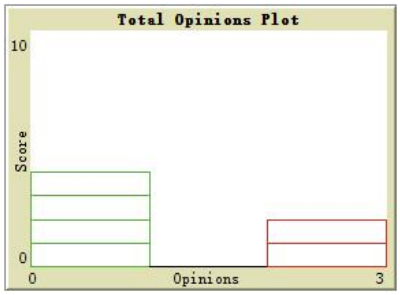
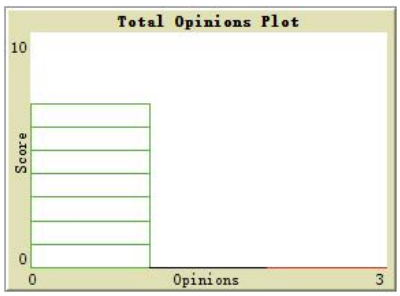
(Continued)

Output Figure	Parameters for Simulation	Times of convergence
	Initial approval rate: 20% Outside connection rare: 70%	Approval (+1): 0 Neutral (0): 0 Disapproval (-1): 8
	Initial approval rate: 20% Outside connection rare: 80%	Approval (+1): 0 Neutral (0): 0 Disapproval (-1): 8
	Initial approval rate: 30% Outside connection rare: 20%	Approval (+1): 2 Neutral (0): 0 Disapproval (-1): 3
	Initial approval rate: 30% Outside connection rare: 30%	Approval (+1): 1 Neutral (0): 0 Disapproval (-1): 3
	Initial approval rate: 30% Outside connection rare: 40%	Approval (+1): 1 Neutral (0): 0 Disapproval (-1): 4

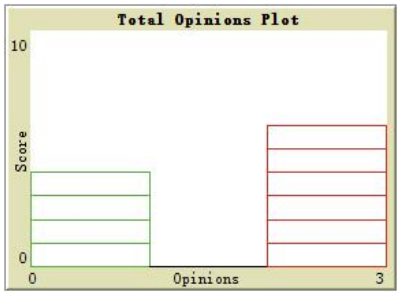
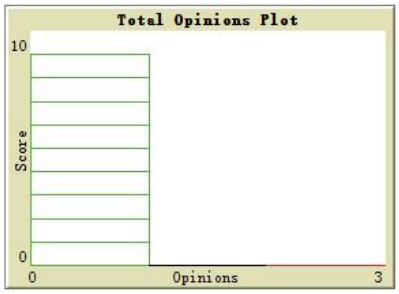
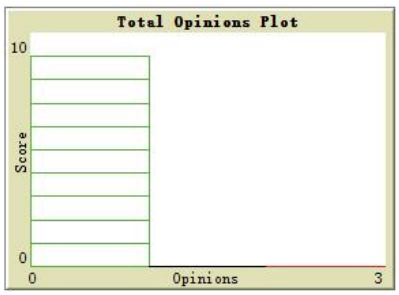
(Continued)

Output Figure	Parameters for Simulation	Times of convergence
	Initial approval rate: 30% Outside connection rare: 50%	Approval (+1): 0 Neutral (0): 0 Disapproval (-1): 7
	Initial approval rate: 30% Outside connection rare: 60%	Approval (+1): 4 Neutral (0): 0 Disapproval (-1): 6
	Initial approval rate: 30% Outside connection rare: 70%	Approval (+1): 4 Neutral (0): 0 Disapproval (-1): 5
	Initial approval rate: 30% Outside connection rare: 80%	Approval (+1): 5 Neutral (0): 0 Disapproval (-1): 5
	Initial approval rate: 40% Outside connection rare: 20%	Approval (+1): 5 Neutral (0): 0 Disapproval (-1): 2

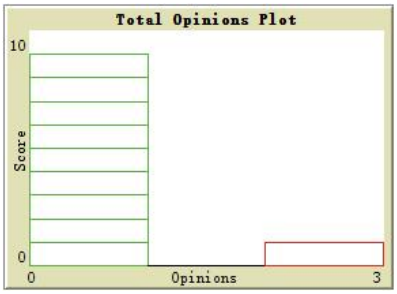
(Continued)

Output Figure	Parameters for Simulation	Times of convergence
	Initial approval rate: 40% Outside connection rare: 30%	Approval (+1): 4 Neutral (0): 0 Disapproval (-1): 2
	Initial approval rate: 40% Outside connection rare: 40%	Approval (+1): 7 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 40% Outside connection rare: 50%	Approval (+1): 5 Neutral (0): 0 Disapproval (-1): 3
	Initial approval rate: 40% Outside connection rare: 60%	Approval (+1): 5 Neutral (0): 0 Disapproval (-1): 5
	Initial approval rate: 40% Outside connection rare: 70%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0

(Continued)

Output Figure	Parameters for Simulation	Times of convergence
	Initial approval rate: 40% Outside connection rare: 80%	Approval (+1): 4 Neutral (0): 0 Disapproval (-1): 6
	Initial approval rate: 50% Outside connection rare: 20%	Approval (+1): 8 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 50% Outside connection rare: 30%	Approval (+1): 8 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 50% Outside connection rare: 40%	Approval (+1): 9 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 50% Outside connection rare: 50%	Approval (+1): 9 Neutral (0): 0 Disapproval (-1): 0

(Continued)

Output Figure	Parameters for Simulation	Times of convergence
	Initial approval rate: 50% Outside connection rare: 60%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 50% Outside connection rare: 70%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 50% Outside connection rare: 80%	Approval (+1): 9 Neutral (0): 0 Disapproval (-1): 1
	Initial approval rate: 60% Outside connection rare: 20%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 60% Outside connection rare: 30%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0

(Continued)

Output Figure	Parameters for Simulation	Times of convergence
	Initial approval rate: 60% Outside connection rare: 40%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 60% Outside connection rare: 50%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 60% Outside connection rare: 60%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 60% Outside connection rare: 70%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 60% Outside connection rare: 80%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0

(Continued)

Output Figure	Parameters for Simulation	Times of convergence
	Initial approval rate: 70% Outside connection rare: 20%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 70% Outside connection rare: 30%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 70% Outside connection rare: 40%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 70% Outside connection rare: 50%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 70% Outside connection rare: 60%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0

(Continued)

Output Figure	Parameters for Simulation	Times of convergence
	Initial approval rate: 70% Outside connection rare: 70%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0
	Initial approval rate: 70% Outside connection rare: 80%	Approval (+1): 10 Neutral (0): 0 Disapproval (-1): 0