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Review Article

A thematic Review on Industrialised Building System (IBS) Publications from 2015-2019: Analysis of Patterns and Trends for Future Studies of IBS in Malaysia

Mohd Zairul

Department of Architecture, Faculty of Design and Architecture, Universiti Putra Malaysia, 43000, Serdang, Malaysia

ABSTRACT

IBS has been theoretically and practically proven to improve the construction delivery apart from reducing the lead of time and cost throughout its supply chain. Under the Malaysian Construction Industry Transformation Programme (CITP) 2016-2020, it is stated that the government is accelerating the adoption of IBS through mechanisation and modern practices. Despite the government's initiative, there have been relatively small amounts of materials published discussing the patterns in IBS publications in Malaysia and what the future holds for IBS. This paper explores a thematic review of the literature regarding new definitions and patterns that juxtaposes IBS in the construction industry in Malaysia from 2015 till 2019 by using the thematic review. The findings from the code-to-document analysis using ATLAS.ti 8 found that the patterns and trends on IBS from the year 2015 to 2019. This paper contributes to analysing the patterns and trends of IBS by identifying the thematic code within IBS publications for recommendations of future studies on IBS in Malaysia.

Keywords: ATLAS.ti 8, construction industry, IBS research, Industrialised Building System, thematic review

INTRODUCTION

IBS or Industrialised Building System has proven its capability in improving its construction delivery by minimising time and cost throughout its supply chain. IBS is also known worldwide as prefabricated (Noguchi, 2003), pre-fab construction (Benros & Duarte, 2009), modern method

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E-mail address:
m_zairul@upm.edu.my

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of construction (MMC) (Musa et al., 2016), and off-site construction (Piroozfar et al., 2012). Under the Malaysia Construction Industry Transformation Programme (CITP) 2016-2020, the government aspired to accelerate the adoption of IBS through mechanisation and modern practices. There are several definitions of IBS in practice and the literature mainly emphasises on off-site (Jonsson & Rudberg, 2014; Musa et al., 2018) controlled environment (Rashidi & Ibrahim, 2017; Yunus et al., 2016). Some define it as a technique of construction where building components are manufactured in a controlled environment, either at the site or off-site, placed and assembled into construction works (Md. Ali et al., 2018). However, in this paper, IBS is defined as an innovative process of building components utilising mass production Industrialised systems, produced within a controlled environment (on or off-site) which includes organised logistics and installation process on-site with systematic planning and management.

Within the Construction Industry Transformation Plan (CITP) 2016-2020 framework on the IBS initiative and Government's effort to enhance the Industrial Revolution IR 4.0, the government is focusing on the implementation of IBS in their sector projects as well as extending the usage towards privately run projects. This initiative, in return, will provide a sustainable value chain in the construction industry in Malaysia. Construction Industry Development Board (CIDB) Malaysia, through the IBS Centre, actively promotes IBS through several programs and activities for the contractors and developers. The content of IBS (IBS Score) is determined based on the Construction Industry Standard 18 (CIS 18: 2010); which can be done manually executed through a web application or a fully automated CAD-based IBS Score calculator. Despite the initiatives, no publication described the patterns present within IBS publications in Malaysia. Hence, the objective of this paper is to explore the patterns and trends in the IBS publications from the year 2015-2019 to be recommended for future studies and set the direction of IBS in both theoretical and practical use.

METHOD

The primary sources of the data were extracted from SCOPUS and Mendeley search. Several Elsevier journals collaborate with Mendeley data to make underlying research data available. Datasets are linked with the article, making it accessible to look for literature in both SCOPUS and Mendeley databases. The critical part is to identify the patterns and construct categories to understand the trends of IBS publications in the country. The tenets of the research are to analyse and interpret the findings for the recommendation of future research in the IBS fraternity in the context of Malaysia. The thematic review incorporates a multitude of research methods at the same time as an expected range of epistemological standpoint. To illustrate the steps involved in a thematic review, this paper performed the analysis based on several selection criteria: 1) publications

from 2015-2019, 2) possess keyword(s) of 'IBS' or 'Industrialised Building System' or 'Prefabricated' in the content, 3) Focusing on IBS discussion in Malaysia. However, the study was limited to Malaysia to help define future recommendations of IBS in the Malaysian context. The literature discovery was performed in the SCOPUS and Mendeley literature search using the following search strings (Table 1).

From the SCOPUS search, the TITLE-ABS-KEY ("Industrialised building system" AND Malaysia AND (Limit -TO (PUBYEAR, 2019) or LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) generated 75 articles which discuss IBS in Malaysia from 2015-2019. From the Mendeley literature search, the initial search came out with the term "Industrialised building system" yielding 171 articles. The next strings of searches used "Industrialised building system" AND "Malaysia" which yielded 90 results. In the final round, the search strings used "Industrialised building system" AND "Malaysia" [year: 2015 TO 2019] which yielded 40 results. 19 overlapping articles were removed and resulted in further filtration from both SCOPUS and Mendeley

Table 1
Search strings from SCOPUS and Mendeley

Search strings from SCOPUS	TITLE-ABS-KEY ("Industrialised building system" AND Malaysia AND (Limit -TO (PUBYEAR, 2019) or LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) Result= 75 articles
Search strings from Mendeley	**"Industrialised building system"**= 171 articles **"Industrialised building system" AND "Malaysia"**= 90 articles **"Industrialised building system" AND "Malaysia" year: [2015 TO 2019]** = 40 articles

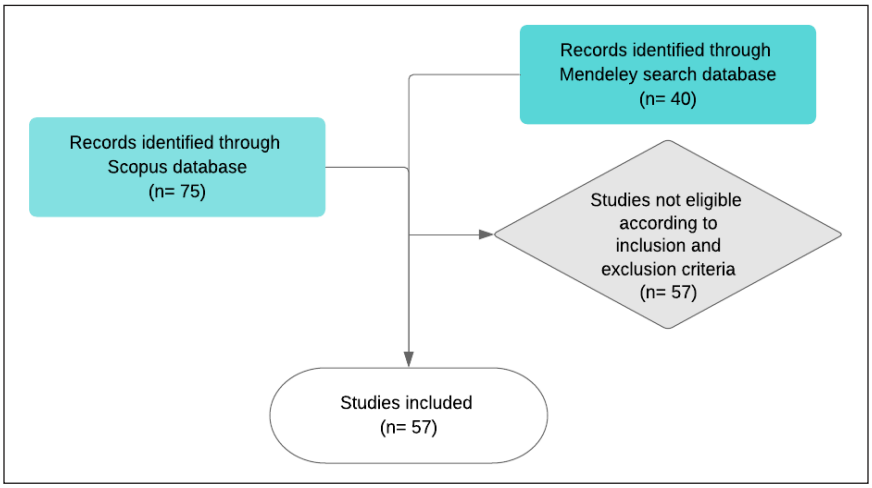

Figure 1. The procedure of identifying the articles for thematic review

search which resulted in 97 articles touching on IBS in the Malaysian context from the year 2015 to 2019 (Figure 1). However, conference publications were removed, and hence this paper chose articles from journals and theses which were reviewed thematically.

This manuscript is termed a thematic review (Zairul, 2020) due to the method employed in this study as thematic analysis. Clarke and Braun (2013) defined thematic analysis as a process of identifying the pattern and construct themes over thorough reading on the subject. Hence, the final count of valid publications came down to 57 from the 115 papers in the preliminary round. Following the first stage of selection, the articles were uploaded into the ATLAS.ti 8 software (textual analysis software) as primary documents which were then grouped into 1) author; 2) issue number; 3) periodical, 4) publisher, 5) volume and 6) year of publication. In doing so, the articles were conveniently categorized to be analysed according to the year of publication and the discussion pattern each year. After many counts of filtration, 57 articles were finalised using the ATLAS.ti (Table 2).

Table 2
Paper reviewed according to year

Year	Articles
2015	10
2016	19
2017	7
2018	17
2019	4
Total	**57**

Based on Figure 2, a word cloud from the 57 documents captured the term 'IBS' which was used 3364 times, while 'construction' was mentioned 3269 times and 'project' 1407 times. Based on the thematic analysis of the selected articles and sequence of frequency, the present discussion was based on the following themes; 1) Application; 2) Issues and Problems; 3) Sustainable; 4) Framework; 5) Management; 6) Review Paper; and 7) Automation. The result of the present thematic review is reported in the results section.

Figure 2. Word cloud generated from 57 articles

FINDINGS

This paper reviews the patterns and trends of IBS publications and applications in Malaysia. After recalling the 57 articles, the trends and patterns have produced 45 initial codings. However, following several rounds of re-coding and code merging in ATLAS.ti 8, the final trends and patterns delivered seven main patterns (Table 3).

Application

Within this theme, the applications of IBS in the construction industry were discussed (Figure 3). In the application theme, the titles are divided into several sub-themes such as application in management, application in terms of product and materials, and application in terms of practice on site. The most discussed topics included the IBS

Table 3
Thematic review of IBS publications from 2015 till 2019

	2015	2016	2017	2018	2019
• **Application**	3	8	2	5	1
• **Issues & Problems**	1	5	1	6	1
• **Sustainable**	1	0	0	2	1
• **Framework**	0	2	0	1	0
• **Management**	1	2	2	5	1
• **Review paper**	0	3	0	1	1
• **Automation**	2	1	0	0	0

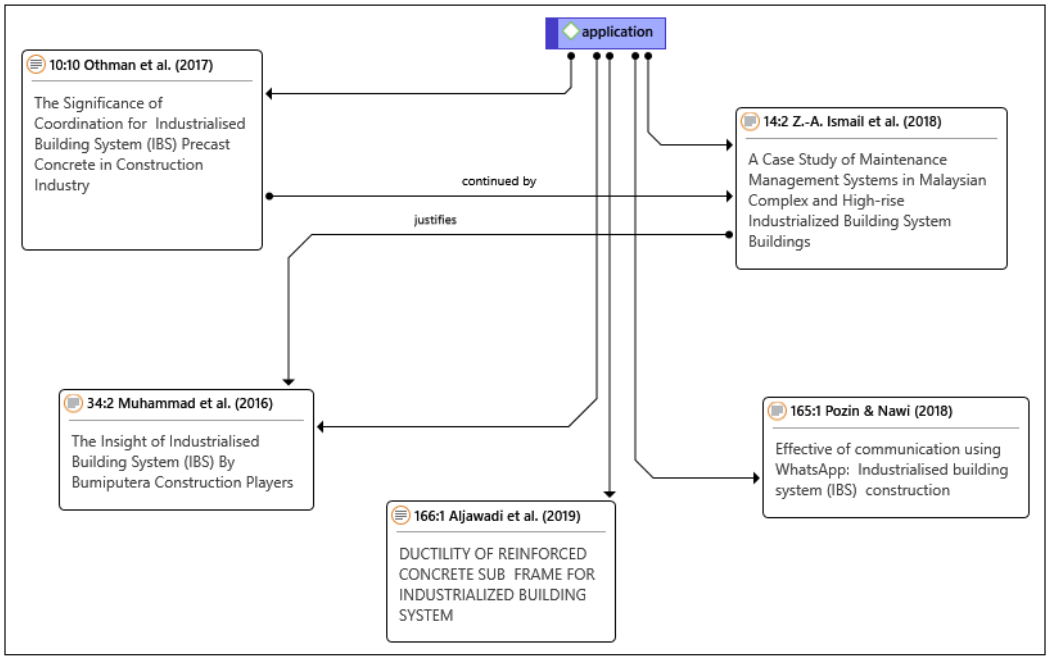

Figure 3. Network view on the application in the practice

applications tested in the industry and the evaluation of its performance (Othman et al., 2017), discussed the coordination for IBS focusing on precast concrete in the construction industry. Another aspect of the application includes the maintenance management system (Z.-A. Ismail et al., 2018) and the involvement of Bumiputera construction players in IBS (Muhammad et al., 2016). Further, Nawi et al. (2018) suggested supply chain management as part of the application strategy and proposed WhatsApp as an effective communication platform in IBS management on site (Pozin & Nawi, 2018).

The competency of architectural firms in Malaysia and the competence of the project manager (Jabar et al., 2015) were also discussed and categorised as an application pattern. Md. Ali et al. (2018) highlighted the lack of skilled workers and mentality among industry key players as the main reason for the impending acceptance of the IBS system. Furthermore, Z.-A. Ismail (2017) proposed I-CMMS for the maintenance of the IBS building. In 2019, Aljawadi et al. (2019), focused their publication on the test scheme of nonlinear elastic sub-frame systems to build an IBS structural building system. Previously, Mohammad et al. (2016), highlighted the high investment in the IBS technical and maintenance remained the main obstacles in the implementation of IBS in Malaysia. Hence, more studies were established to exemplify the usage of the system in practice; therefore, highlights several issues and problems as being discussed in the next section.

Issues and Problems

Several publications raised issues on contractual and economic factors (Figure 4). Shamsuddin et al. (2015), highlighted the methodology for cost planning of IBS projects in Malaysia. Costing and economic factors were among the main reasons for the readiness among the key players to adopt the system. Besides, sustainability and generating economic turnover were some of the obstacles mentioned in the industry (Shamsuddin et al., 2018). Moreover, there is also a suggestion to review the existing standard form of contract to suit the IBS system in Malaysia (Fateh et al., 2020). This suggestion was previously asserted by H. L. T. Ariffin et al. (2019) on the importance of having dedicated procurement specialised in IBS. Most of the articles were found focusing on issues and challenges on the implementation of the system. Several incentives have been offered by the government to increase the participation of industry players towards incorporating IBS in their system, e.g. manufacturers developing their own facilities and manufacturing plant that has incorporated IBS into their system will enjoy tax exemption of 70% or 100% for a period of 5 years. Although such incentives are provided by the government, there are still drawbacks in the industry and this theme remains popular among the researchers in Malaysia.

The issues and challenges include competency and performance (H. L. T. Ariffin et al., 2019), implementation (Nawi et al., 2013), and the acceptance among the

key players (Nasrun & Nawi, 2015) and investigating factors of delays (Nawi et al., 2019) . In summary, issues and problems can be categorised into procurement (Fateh et al., 2020) management (Fauzi et al., 2017; Noor et al., 2018); and system (Ern et al., 2017; Md. Ali et al., 2018; Razak & Awang, 2014).

Based on the results obtained by a group of researchers from a survey conducted on IBS manufacturers, the researchers identified that integration, competency, and communication were among the challenges faced by the IBS key players in the industry (Jin et al., 2017). The fragmented disciplines in the construction team have further caused the effectiveness of the supply chain management (SCM) at stake (Fauzi et al., 2017). The issues on communication are associated with cost, time, product, design, safety, profit, business performance, and relationship (Yunus et al., 2016). Despite the challenges, another group of researchers suggested that technology transfer or benchmarking on IBS construction and exchange of information to be among the best practices for successful systems (Amin et al., 2017). To further support this suggestion, a recent study revealed issues of IBS using conventional contracts like PWD or PAM contracts which were found to be unsuitable for work and procurement of IBS (H. L. T. Ariffin et al., 2019) Nevertheless, the issues and challenges pattern is among the most popular publications or research conducted by IBS researchers in Malaysia, considering the adversarial factors involved among the key players in the construction issues in Malaysia.

Sustainable

The next pattern highlighted sustainability topics as a popular theme for IBS publications. In 2017, IBS was redefined and was recommended to be integrated with CAD into IBS applications in order to improve the performance and to reduce wastages from the onset (Rashidi & Ibrahim, 2017). In Malaysia, sustainable issues were revolved around the application of IBS in housing construction projects (Wen et al., 2015). Further, S. Ismail (2018) developing a framework for sustainable IBS to facilitate infrastructure redevelopment works in Malaysia. This has led to a case study on waste generation based on IBS constructions in Malaysia (Maniam et al., 2018). The study on IBS for housing has been highlighted again in the publication by Aris et al. (2019) on the importance of improving the fabrication technology among the IBS key players. IBS has also been proven to reduce wastages, especially by using timber IBS compared to steel construction (Muhaidin & Chan, 2018). Z. A. Ismail (2018) proposed a holistic framework to adopt IBS as a concerted effort to promote sustainability in the construction industry (Figure 5). Hence, more publications to support the green and sustainable construction of IBS are needed to enhance the awareness of its benefits.

Framework

The framework is the next theme under the pattern of IBS publications in Malaysia. Under this theme, several frameworks were proposed such as organisational framework (Musa et al., 2016), life cycle

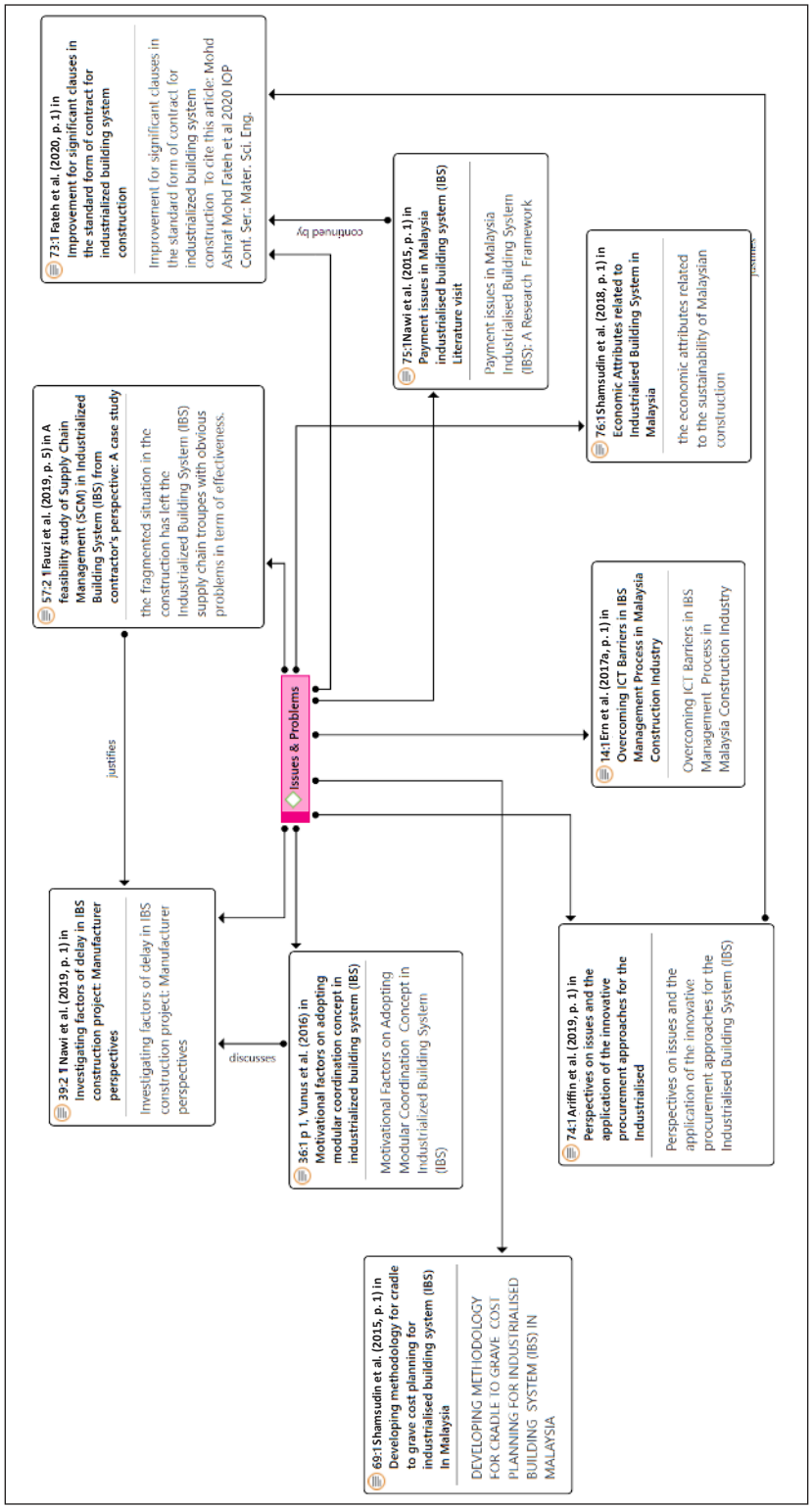

Figure 4. Network view on issues and problems of IBS

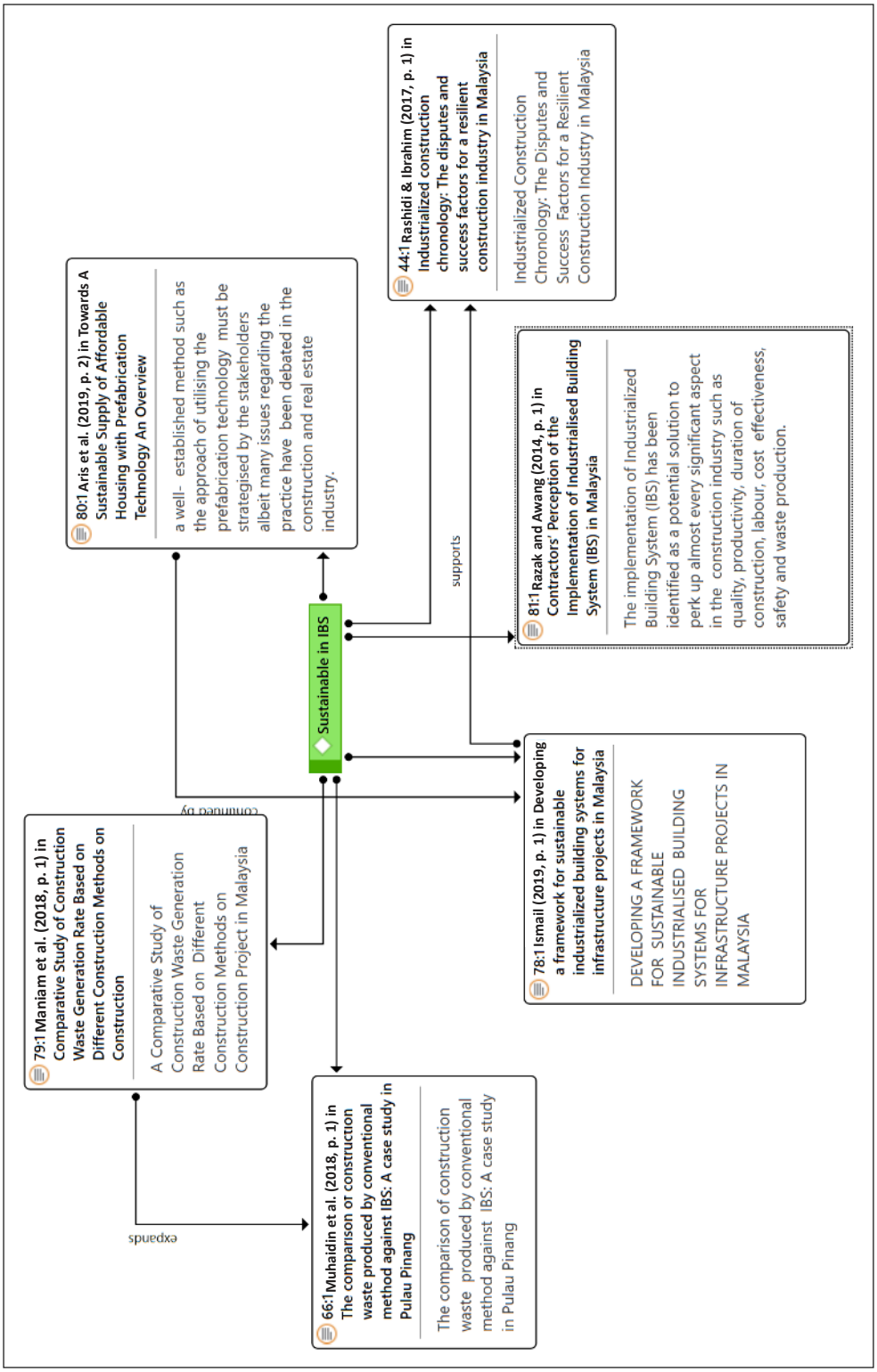

Figure 5. Network view on main publications that discussed sustainable pattern in the literature

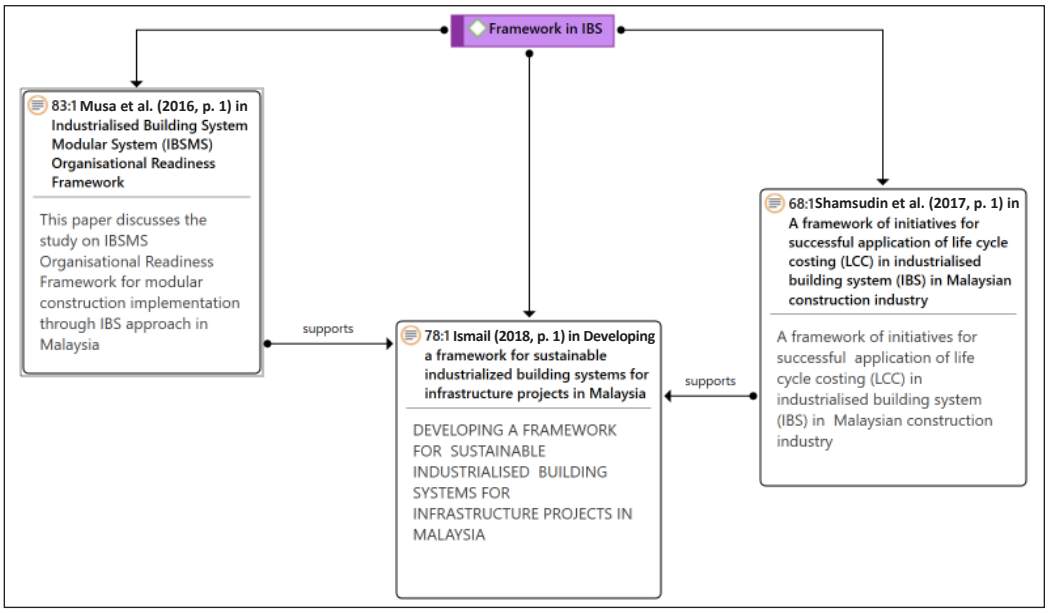

Figure 6. Network view on the framework in IBS

costing in the IBS framework (Shamsuddin et al., 2017), and a holistic, sustainable IBS framework (Z.-A. Ismail et al., 2018). Based on these frameworks, several potential solutions were drafted and discussed in previous studies. Using the organisational framework, organisations that execute modular construction could operate more efficiently in coordinating modular systems (Musa et al., 2016). A holistic, sustainable IBS framework promotes the incorporation of IBS in the construction industry (S. Ismail, 2018), while comprehensive cost estimates will aid in decision making between IBS or conventional construction (Shamsuddin et al., 2017). In summary (Figure 6), recent publications focusing on building a framework to support the sustainable effort as mentioned in the previous section.

Management

Innovation in management was among the popular themes discussed by researchers in IBS (Figure 7). Several innovations in management were proposed, e.g. supply chain management (SCM) (Fauzi et al., 2017; Nawi et al., 2018) and quality function deployment (QFD) (Haron et al., 2014). Most of the topics covered under this theme discussed a way to achieve the required quality and customer satisfaction using the IBS management strategy. Yunus et al. (2017) further suggested that the integration of lean management should begin at the early inception stage. The familiarity with the system is also the key to the success of the project. Even though this pattern overlapped with other sections earlier, the research indicates how the IBS projects were managed on-site, and this involves quality, plan of work, way forward, and IoT in the construction industry.

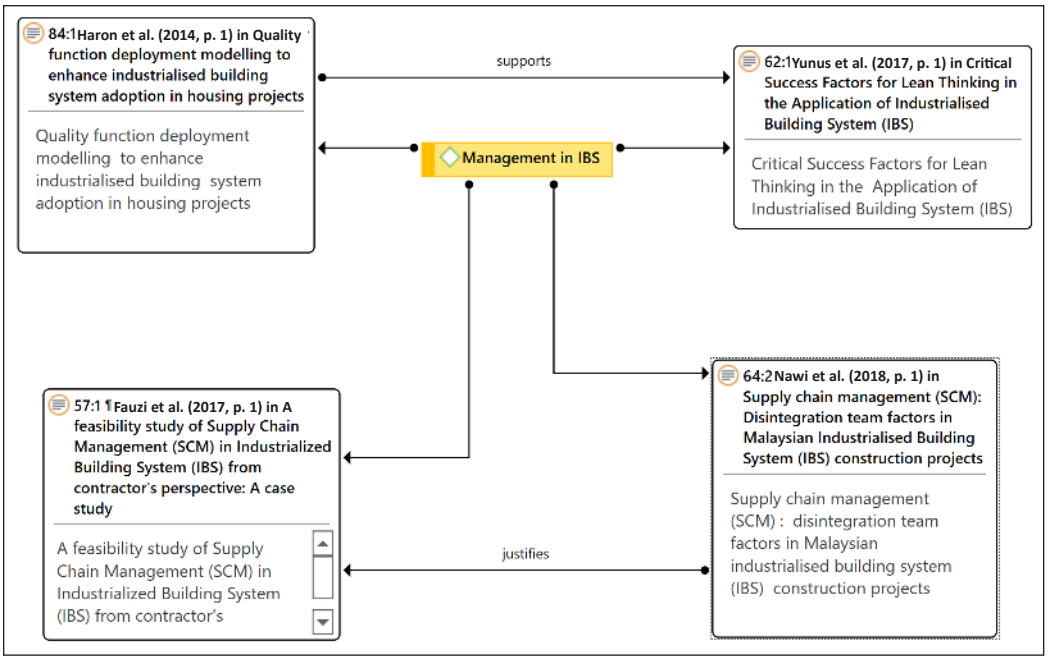

Figure 7. Network view on management

Review Paper

The review paper was also amongst the favourite type of articles for the IBS researchers in Malaysia. Considering the review on IBS in Malaysia in 2014, which focused on the migration from the conventional system to mechanisation such as IBS (Kamaruddin et al., 2018) and factors affecting quality management of IBS construction projects (Azman et al., 2018). Another publication highlighted the formulation of the standard form of contract for IBS (Fateh et al., 2017). Z.-A. Ismail et al. (2018) provided a review of the contractor's social networking on IBS infrastructure maintenance projects. And recently, the review paper is focusing on factors affecting quality management using IBS (Azman et al., 2018) and review on delay factors in IBS construction by Nasir et al. (2016) Similarly, this theme was also discussed again in subsequent publications (Amin et al., 2017; Fateh et al., 2017) as the main challenges in the contractual stage. Fateh and Mohammad (2017) posited that developing a new form of contract was necessary to ensure the smoothness of the project (Figure 8). In terms of technology application, Ghazali et al. (2016) mapped the critical factors in IBS formwork application. However, none of the review papers analyse the pattern in the IBS articles, particularly in Malaysia.

Mechanisation and Automation

In recent years, the idea of mechanisation and automation was proposed for the future of IBS construction in Malaysia. The tendency of high quality and precision has been highlighted as the marketing

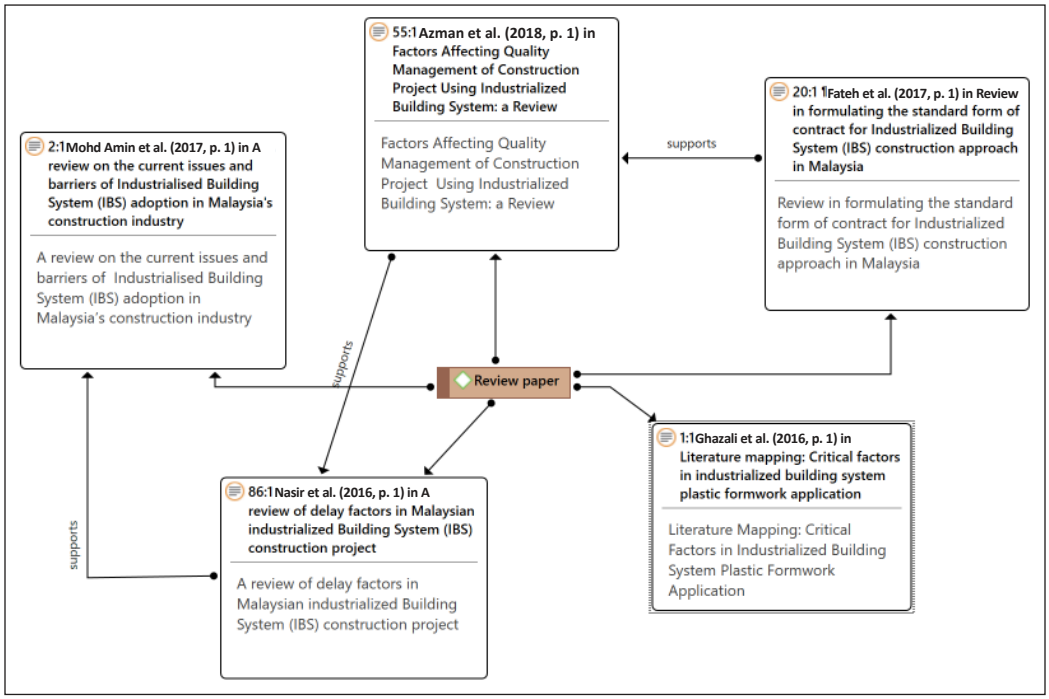

Figure 8. Network view on the review paper

strategy to increase customer satisfaction. This strategy in the field of automation can reduce dependency on unskilled labour (Chia et al., 2012) and poor quality in the construction industries (Haron et al., 2014). Although robotics and automation have already become common in other countries such as Japan, Australia, and Europe, the business model is still at its infancy stage, especially in Malaysia. The construction industry in Malaysia, which is one of the oldest sectors and biggest industries in the country, is still unfamiliar with the benefits of automation and robotic mechanisms. In the era of Industrial revolution 4.0, the dependency on cheap labour is unnecessary; therefore a test conducted by Marsono et al. (2015) on the structural performance through manufacturing can open up a new business model that supports automation and mechanisation which has been proposed by Zairul (2017) in his thesis (Figure 9). Earlier several articles discussed the enablers and barriers for onsite mechanisation (Waris et al., 2015) and the awareness of onsite mechanization (Waris et al., 2014). Hence, the future topics for publication on IBS shall focus more on the automation and mechanisation strategy towards component-industrialisation, pre-assembled, clean production, and circular economy. IR 4.0 concepts should be combined with construction production; innovative knowledge can be integrated into the IBS construction to improve the level of integration and finally to achieve a sustainable development goal (SDG).

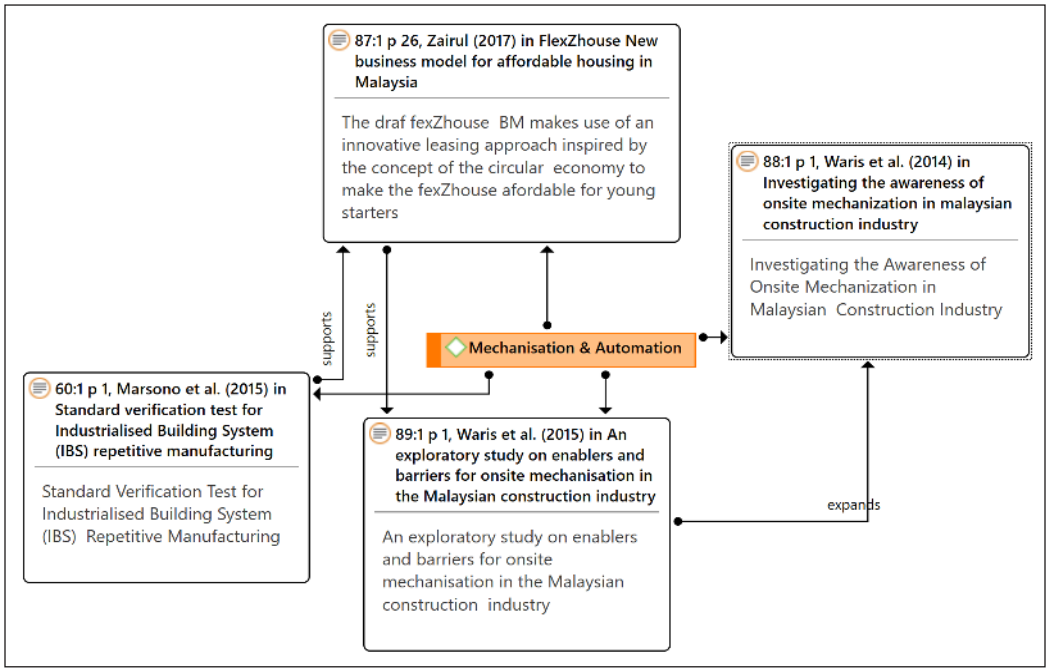

Figure 9. Network view on mechanisation and automation

CONCLUSION AND FUTURE STUDIES

This article reviewed the patterns and trends in IBS publications in Malaysia to support the idea of the Industrial revolution IR 4.0 in the construction industry. The findings from the code-to-document analysis in ATLAS.ti 8 indicated that the patterns and trends on IBS highlighted application, issues & problems, sustainability, innovation management, review papers, and mechanisation & automation. This paper has contributed towards analysing the patterns of IBS by extensively identifying the thematic codes within IBS publications in Malaysia from the year 2015 to 2019 further to assess the trends of the publications to date. However, based on the findings of this study, there is a gap in the study of automation and mechanisation in the construction industry in Malaysia. Imperatively, the future of IBS is moving towards full automation and robotics. However, the move towards full automation requires a big investment from the company and higher key resources. Hence, based on the Malaysian context, a new business model is needed to support the future of IBS using robotics and automation in IBS construction. Therefore, it is a good move to explore the potentials of robotics construction which will enhance the IBS system in the country to support IR 4.0 and sustainable development goal no: 9 across further collaboration with the industry, through innovation and improvement of the infrastructure.

PRACTICAL AND THEORETICAL CONTRIBUTIONS

This paper analysed the patterns of IBS by extensively identifying the thematic codes within IBS publications to assess further the trends of the publications from 2015 to date. The findings will benefit the future research direction and identify the gaps in IBS studies in Malaysia.

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