

A Taxonomy of Construction Supply Chain for Affordable Housing in New Zealand

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Abstract—Affordable housing is a challenging problem which needs to be solved through both government and industry initiatives. Improving construction supply chain has the potential to expedite the supply and achieve affordable housing. However, there is need to develop linkages between affordable housing problem and construction supply chain problems. A problem taxonomy approach has been used to develop problem clusters (as housing, affordable housing and construction supply chain) through detailed literature review of studies and reports related to New Zealand. A problem taxonomy is proposed which showed generic, main and specific configuration problems of construction supply chain in New Zealand. This taxonomy helps to develop relationships, research hypothesis, questions and ontologies to investigate affordable housing problem, and drive solutions through configuration of construction supply chain.

Index Terms—affordable housing, construction supply chain management, problem taxonomy, literature review, New Zealand

I. INTRODUCTION

Construction industry is among the top five economic sectors in New Zealand with 6% contribution in GDP [1]. Construction has overall contribution of 52% in gross fixed price formation with 26% covered housing sector [2]. Housing has significant growing trend [3], [4] and 20% sales volume growth from year 2014 [5]. Nevertheless, shortage of housing supply, due to immigration and population, remained an issue [6]. In addition to this affordability is also a major problem [7], [8]. Affordable housing has received much attention on global scale [9] including both developing and developed countries, New Zealand is not exceptional [8]. Overall housing market in New Zealand is ranked among least affordable markets in the world [10]. Reference [11] provided main drivers for affordable housing supply as policies of government; land availability; infrastructure provision; fragmentation of land ownership within the urban area; cost and availability of finance; compliance costs; development contributions; construction costs; and cost of labour. Configuration of construction supply chain is an industry (non-governmental) initiative [12] to achieve affordable housing through enhancement of construction industry productivity which is based on

innovative construction materials and techniques [13]. This paper is an attempt to propose a problem taxonomy of Construction supply chain to investigate the affordable housing problem through detailed literature review in context of New Zealand.

A. Affordable Housing – A Multifaceted Issue and Problem

Appropriateness of a particular house depends on dimensions as affordability, accessibility, amenity and adequacy [14]. Affordable housing is the most challenging due to inter sectoral relation and interdisciplinary linkages. Affordable housing has remained a global issue and always been addressed by international, governmental and political platforms, but at construction industry level this problem has not been given significant attention. The main reasons are the less profitability and high volatility of housing sector.

Residential facility is unaffordable if the household [low-income] spends more than thirty percent of the income to purchase (including mortgage) or for rent [15]-[17]. On other hand more accepted approach is adopted by Demographia Survey [18], considering median house prices and median household incomes. Another perspective is the residual income to cover basic living after spending on housing [12].

Housing itself is neither affordable nor unaffordable [19] but, this concept was evolved as a result of economic factors as employment, wage level, house price, and house rents. Housing is also a base for social interaction, education and social development which enhances its significance at macro level [20] adds value to quality of life and sense of social/community wellbeing at micro level (individual). Every individual of any society has the right to access affordable, sustainable, good quality housing to full fill basic needs [as envisioned by NZ government [12]. Unfortunately, affordable housing is still a dominant issue in urban planning and development at national level, and housing policy globally [21].

Affordable housing is categorized in to social housing (including state and community housing) and private housing but all of these are differ in terms of financing and usability [22] but similar in building construction and related problems. There should be no compromise on comfort, quality and lifespan of facility [23]. However, various disadvantages are also associated with affordable housing such as inappropriate location, lack of community facilities and standardization in general [24].

In addition to this transportation cost is also a major problem [25]. Nonetheless, major challenges for construction of affordable housing are lack of innovative technologies and material; inconsistent cash flow; demand urgency; shortage of skilled labour; and lack of quality control measures [26]. Regularity barriers also predominantly impact the supply of affordable housing such as costs of development and inspection [27].

There is a potential to make significant improvement in construction supply chain performance of house building in order to address problem of affordable housing. Main issue is lack of attention by researchers [28], but over the last decade increase in competition, demand and mobility have forced all stakeholders to address construction supply chain problems and issues at operational level [29]. For example, [30] has developed a simulation model to enhance efficiency of supply chain of manufactured houses. Main performance indicators are related to perspectives as financial, customer, internal business, external business and innovation [31], and these perspectives contributes somehow to the problem of affordable housing.

II. RESEARCH OBJECTIVE

This is a preliminary study to investigate the problem of affordable housing through lens of construction supply chain management in context of New Zealand construction industry. Appropriate approach for configurable system in building construction supply chain is to focus on specific product (i.e. residential facility) and problem (i.e. high cost or unaffordability in customer context) [32] but the relation need to be developed with CSCM. Main objective is to develop a problem taxonomy comprising problem domains at generic, main and specific levels.

III. RESEARCH METHODOLOGY

Developing taxonomy and ontology based on knowledge derived from literature review helps to identify the research gaps and problems. A taxonomy is a shareable structured (hierarchical) representation of knowledge that provides a shared terminology or group of entities [33], [34] within a unified framework [35]. This is taken as classification system/scheme to identify differences and attributes or properties to develop clusters and relationships through categorization and decomposition [36], [37]. This helps to comprehend data for development of concepts related to particular industry [38], [39], lead to theory development, hypothesis testing and parsimonious description without losing main information or characteristics [40]. Supply chain system taxonomy aims to provide a multidisciplinary representation of supply chain activities and characteristics [41], with separation of problem and classification domains [32].

A detailed literature review has been done to develop a construction supply chain problem taxonomy based on governmental reports, research studies, conference papers and journal articles from New Zealand or related to New

Zealand. Main research key words were 'affordable or low cost or low income or economic', 'housing or residential facility' and 'construction supply chain or building supply chain'. Around seventy relevant documents were retrieved from research databases as 'Google scholar', 'Web of knowledge' and 'Scopus'. Three main problem information clusters were defined as 'Housing', 'Affordable Housing' and 'Construction Supply chain' along with domain classification as generic, main and specific. Moreover, an attempt has been made to develop connexion among classified information for identification of research gaps.

IV. PROBLEM CLUSTERS

Three main problem clusters has been defined to understand configuration problems of construction supply chain management and linkage with main and sub problems of affordable housing, in addition to common housing problems

A. Housing

Most common housing problems reported in literature are related to following aspects;

Housing sector has forward and backward links with economy growth but volatile nature due to fluctuation makes it unstable [3], [42] and significantly affect the building product and service industry. Moreover, shortage of skilled manpower [3], [43] cause low productivity due to inconsistent nature of work.

Poor design with lack of consideration on medium density and multi-units rather on separated housing [44] reduced scale of economies; lack of focus to enhance capacity, comfort and outer connection [45]; lack of standardization [27]; lack of innovation [3], [12] along with inappropriate urban design [46] cause lower dweller satisfaction.

Using inadequate materials and construction methods lead to poor quality and also question structural integrity and durability [12], [45]. Increasing number of post construction defects reporting [47] is an evidence of poor quality of work during construction and indicates lack of innovation in construction [12].

Housing sustainability is not fully addressed in terms of aspect of location, purpose, materials, energy efficiency, self-sufficiency, durability, availability and affordability as well [12], [46].

Housing has various problems when affordability factor is associated as user belongs to middle or lower class of society. This has been taken as a priority issue at policy level but actual benefit is not provided. Even the dwellers of social and community housing are not satisfied. Serious efforts from all stakeholders are needed to address the problem efficiently and effectively.

B. Affordable housing

This serious problem has emerged in last decade has been reported in various studies. According to Affordable housing inquiry report [13], affordability scale is comparatively varied across New Zealand with Auckland being the least affordable city. This is one of main

concerns for citizens who are younger, single, low income holder, Auckland dweller, or belong to Non-New Zealand European ethnicity. During the last decade, the pressure of affordable housing increases on middle – income holder which raised the severity of this problem. Dunbar (2011) found that lack of focus on medium density (multi-unit) housing enhanced affordability problem in New Zealand and the main concern for this initiative (if taken) is innovation in terms of type, style and location (like suburbs). Nevertheless, transportation cost for commuting to or from employment hubs (like central business districts) is also a key factor which was not considered in affordable studies (Mattingly & Morrissey, 2014). Construction strategy group [48] indicated that growth of housing business was dragged due to little development scale and fragmented nature of industry with many small house builders, as full potential of resources are not utilized. Moreover, speculative nature of investment enhanced residential building volatility [3] and cyclic nature of this sector.

Reference [49] has reported some best practices in order to achieve affordable housing. These include intensive use of land; reduction in cost of labour, material and occupancy; reduction in reliance on services and transport and reduction or elimination services fee. Likewise, affordable housing inquiry report [13] has defined approaches to reach affordability goal through tax reforms for investment; availability of land considering Greenfield and brownfield; appropriate location and zoning; proper administration of building regulations; good quality private rental housing; social housing and improvement in construction supply.

C. Construction Supply Chain

Construction supply chain practices are at tactical level in New Zealand because of critical aspects such as high expectations, low economic size and physical isolation [50]. Lack of overseas strategic alliance partnership, information sharing and trade partnering are also common issues of supply chain [51], [52]. Interdisciplinary issues are also under investigation like relationship of construction supply chain and sustainability [53]. Construction supply chain of building housing is fragmented by nature and causes management problems leading to stifle creativity. Thus, resulting in huge construction costs and lower building quality [13]. Actors of construction supply chain of residential projects have varied perceptions regarding collaboration approach for material supply and purchasing like contractors were least interested to collaborate with other members [54]. Advance technologies like BIM applications are also not considered in construction like supply chain planning and management [55]. Improving construction supply chain through economic measures have limitations in application like Real options [56].

Responsibility of affordable housing is dedicated to all partners of building supply chain under corporate social responsibility, but issues like lower productivity of industry and strict government regulations cause more

complications [57]. Need of all scale housing is evident but without involvement of contractor (being main actor in construction supply chain) through incentive schemes, affordable housing is unattainable [27]. Government Initiatives taken by Construction strategy group [48] to reduce costs of material and labour by twenty percent through Productivity partnership is not sufficient if industry is not engaged at micro and macro level with aim to reach affordable housing. Affordable housing inquiry report [13] provided innovative approaches to supply chain management which are potential areas for future research;

- 1) Introduction and integration of specialist subcontractors to enhance SC flexibility
- 2) Effective management of subcontractor work to avoid coordination problems and rework
- 3) More involvement of subcontractor to achieve project goals to avoid conflicts
- 4) Induction of standardized housing to increase scale and productivity
- 5) Integrated project delivery through collaboration among SC members in design and construction phase.

In addition, few researchers also recommended aspects of trade partnering to attain external focus [52] and efficient logistic management [58].

Moreover, a report by Auckland council [59] indicates, aspects which should be considered in order to reform supply chain of as alleged monopoly power; less licensed building practitioners; inconsistent design and manufacturing process; low scale economies and limited scope of economies; quality risk of construction and design; poor quality assurance and project management practices. Most importantly, partnering is recommended among supply chain members (both local and overseas) to improve overall productivity through new production technologies (like offsite prefabrication and BIM). Facilitation to overseas supply chain members will provide innovation solutions to housing and mitigate any market power.

V. PROPOSED PROBLEM TAXONOMY

Proposed problem taxonomy identified specific problems in construction supply chain which are pre requisite for configuring performance improvement (Fig. 1). Affordable housing is great challenge for both governmental and non-governmental entities but the level of responsibility differs for both. This public domain issue compelled governmental bodies to strive for initiatives like social housing, zoning and policy making, but without non-governmental initiative like improving productivity in construction industry through innovative methods, technologies and management approaches, affordable housing will remain a severe problem. Overall, housing market inability to respond the demand (both high and constant) is the most significant factor contributing to unaffordable housing, alongwith the changes in housing policy [57].

Intra-cluster and inter-cluster relationships has been observed in proposed problem taxonomy.

Housing cluster indicates problems such as economic stability, low productivity (in terms of both service and production), poor design of residential facility, poor quality of work, lack of standardization in building elements, lack of innovation throughout project life cycle

and varied provision of sustainability. These problems are somehow interrelated to each other influencing the affordability problem of housing on individual or combined basis.

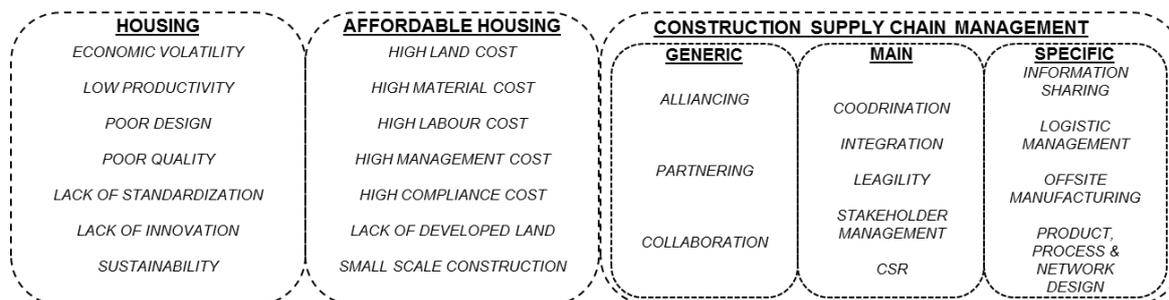


Figure 1. Problem taxonomy of construction supply chain management

Affordable housing is one of the significant problem of housing but linkage with cost makes it more severe. Main constituents of housing cost are the 3M's (management, manpower and material) in context of construction supply chain. Costs of land, development and compliance are also important in over housing supply. Lack of developed land across the country is another hurdle in the supply of housing. Although government develops land but at very slow pace which is not coping with demand. Moreover, low productivity in construction adds on. Small scale of construction of housing means detached or isolated houses, which indicates lack of medium-rise and multi-unit housing. Moreover, small contractors or developers are mostly involved in housing sector which should be replaced by large firms to increase the scale of economies.

Construction supply chain performance of housing needs improvement to address increasing competition, growing demand and high mobility [29], [60]. Studies showed affordable housing is linked with problems in construction supply chain management as alliancing, partnering and collaboration among supply chain members of housing projects [13], [51], [52]. These problems are related to supply chain partners' relationship and coordination. Alliancing is a temporary contractual relationship for a specific project and constellation of firms having one or more alliances (learning, positioning and supply) has the potential to penetrate in affordable housing market [61]. Partnering is also a contractual approach in order to avoid short term opportunistic behavior. This also encourages partners to cooperate for common goals [62] like affordable housing. Collaboration is also long term but beyond relationship to adapt with operational process linkages [63] in order to achieve value chain for project targets [64] such as affordable housing. Skills and attitude are also essential for partnering and collaboration due to adversarial culture of parties in construction [65]

There is a need to investigate the relationship of main and specific problems with generic problems of construction supply Chain management. Studies have shown common main problems to be coordination (which is needed to develop relationship among partners); integration of subcontractor or supplier (to develop trust

and confidence through visibility and without information delays and distortion); leagility (for total supply chain strategy to address complexity and uncertainty); stakeholder management (specifically subcontractor to attain more involvement and common goal); and corporate social responsibility - CSR (to make supply chain members realize their social responsibility for affordable housing).

Specific problems derived from literature review such as inadequate information sharing across the supply chain members which highlight lack of Building information modelling implementation by construction parties [66], which supports collaboration among partners [67]. Logistic management for materials is an essential aspect for business perspective of supply chain [68]. Off-site manufacturing helps to customize the building elements to improve productivity [68]. Furthermore, industrialization (modularization) has potential to support construction supply chain integration (partnering and continual monitoring) [60]. In a particular AEC firm context, product (affordable housing) is designable which addresses the variable requirements of diverse customer; manufacturing and construction processes are defined to achieve that product; and lastly supply chain network is optimized for rapid construction and high quality at competitive cost.

In addition, this problem taxonomy helps to develop hypothesis and research problems in order to configure construction chain for affordable housing. For example, low productivity (in housing cluster) cause high material and labour costs (in affordable housing cluster). Furthermore, this relationship address collaboration problem in construction supply chain management domain at generic level. Specific problems related to collaboration is coordination and integration which is impossible without seamless information sharing among supply chain members through innovative technologies (as BIM), materials (as light gauge steel), method (as lean construction) and technology (off-site manufacturing).

VI. DISCUSSION

This preliminary research helps to understand the affordable housing problem backward (in housing) and

forward (in construction supply chain) linkages which addresses the industry perspective in a holistic way. Inefficiencies of supply chain are identified through taxonomy problem levels but possible relationships and relevant problems need to be confirmed either through literature review or appropriate research approach (qualitative/quantitative). Development of problem taxonomy has been chosen to understand the classification of related knowledge in construction supply chain perspective. Current study is based on studies and research literature related to New Zealand which limits its scope. Identification of right research problem/s of construction supply chain, linked with affordable housing will lead to more relevant research approach for further study.

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