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## **Knowledge influences on perception of innovation drivers for sustainable housing development models**

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**Abstract:** This paper demonstrates the impact of knowledge sharing on the perception of innovation drivers for affordable housing, with a focus on the community land trust shared equity housing model (CLT SEHM). In the context of a competitive housing sector, the research identified and validated drivers for affordable housing innovation through CLT SEHM development. Moreover, data was sought through semi structured interviews and a questionnaire survey. The research employed binary logistic regression to test if there are significant effects of CLT SEHM knowledge on respondents' perceptions. The paper confirms the influence of knowledge on individual perceptions of innovation drivers. Consequently, the predisposition of policy makers or communities to support innovation in affordable housing delivery could be positively influenced by the level of knowledge available to potential project beneficiaries and housing development stakeholders as a whole.

**Keywords:** innovation; knowledge sharing; sustainability; community land trust; CLT; shared equity housing model; SEHM; housing development; binary logistic regression; UK; England.

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## **1 Introduction**

The housing sector in the UK faces pressing challenges revolving around affordable housing deficits and partial failure of policy. Housing deficits in this study's context refers to shortages in affordable housing supply, which typically affects low income individuals and households. As a result, these categories of people are unable to live in decent homes and engaging communities. Despite continual government effort, research still reflects a shortfall in housing delivery in the UK. There is limited effectiveness of traditional models achieving intended policy goals of reducing lingering deficits. Thus, the urgent need for large scale innovative drivers targeted at alternative housing delivery models that might be able to improve the current status quo within the housing industry. This study recommends the concept of innovation obtainable in company capacity to be adapted to housing model delivery efficacy. According to Burgelman et al. (2009) and Wallin et al. (2011), innovation capability is interpreted as a comprehensive set of characteristics that support and facilitate innovation strategies routinely. In an undefined context, the 'capability' of a concept to be flexible to innovation would require developing an understanding of innovation drivers to help overcome limitations and barriers. Moreover, the identification of the aforementioned issues enables the amenability of housing delivery models to innovative solutions – in a bid to improve competitive advantage – where the jostle for resources such as land and funding limitation is at an all-time high.

In the UK, research findings consistently suggest that policy shortcomings, huge deposits, inflationary house prices and strenuous lending conditions are in part responsible for the housing deficit phenomenon. To this effect most of the innovative potentials – that can help address some of these problems – which are inherent in alternative models end up not maximised. Considering the study's focus community land trust shared equity housing delivery model (CLT SEHM), which is a community-based housing (CBH) system where groups or aspiring tenants join together to develop, rehabilitate, manage, and/or own affordable housing. The SEHM initiatives comprises of different models (development trusts, housing cooperatives and other mutual affordable housing models) each with their own strengths and weaknesses. The defining attribute of the research focused CLT SEHM is its stronger cooperative approach which epitomises local community membership, empowerment, democratic stewardship of assets and the evidence that it effectively combats foreclosures – through its permanent affordability structure which epitomises cost/economic sustainability – unlike other mainstream and traditional counterparts (Varady, 2012). Notwithstanding, the CLT SEHM appears relegated to the background in terms of mainstream applicability in the UK, and has largely been overlooked despite its potential.

To foster innovation drivers for this underrepresented alternative housing delivery model, researchers would have to respond holistically to the challenge of ensuring that alternative models are not relegated to the background due to limitations that can be overcome. Perhaps, these alternatives are victims of their own networks. Moreover, could their underrepresentation be possibly linked to competition and the over reliance on traditional delivery platforms whose structures and operations could serve as potential or active barriers.

Developing an understanding of these seeming limitations could help shed light on the urgent need for more strategic reforms on the innovative capacity within the housing sector. However, defining information and the state of knowledge sharing on

novel/renewed housing delivery models such as the CLT SEHM – that appears under researched – is however crucial to the sector’s receptiveness to innovation. On this note, this research focuses on how the level of knowledge available to practitioners and policy makers can potentially play a defining role in the successes of alternative innovative housing delivery models.

## **2 Literature review**

In the UK, according to the Housing and Regeneration Act 2008, Part 2, Chapter 1, Clause 79, this defines the CLT as a corporate body.

- Established for the express purpose of furthering the social, economic and environmental interests of a local community by acquiring and managing land and other assets in order – to provide a benefit to the local community to ensure that the assets are not sold or developed except in a manner which the trust's members think benefits the local community.
- Established under arrangements which are expressly designed to ensure that: any profits from its activities will be used to benefit the local community (otherwise than by being paid directly to members) individuals who live or work in the specified area have the opportunity to become members of the trust (whether or not others can also become members), the members of the trust control it.

The CLT SEHM is considered to be a non-profit model. Due to difficulties inherent in competitive housing markets, the model is better adopted in partnership with municipalities/local governments. Other variations require adopters of this affordable housing delivery model to acquire land with a cost limiting strategy of a 99-year ground lease. As a result, the cost of land in the overall price mechanism of the delivery model is ultimately nullified at varying degrees. Therefore, eventual beneficiaries will have to develop housing ‘without the cost of land’, in order to maintain permanent affordability; therein lays the model’s unique strengths. In a volatile housing market, the mechanism is that resale profits are limited; hence incentives to ‘flip’ the housing at current market rates are drastically reduced.

Policy wise, England cannot be viewed as a microcosm of the UK in its entirety; however as a non-sovereign country, they both share certain socio-economic trends and experiences. For example In the UK, there are about 137 existing CLT housing projects, with 92 still at developmental stage, while in England, over 229 homes have been supplied by 18 CLT projects with varying tenure types including, 35% (81 homes) for rent and 59% (135 homes) are for part sale and 6% (13 homes) are for outright sale. This demonstrates that England relatively does have a significant representation of the CLT SEHM, which gives a general reflection of the state of under representation for this model across the UK. In comparison to other European countries, Sweden, Norway and Austria fared much better than the UK in median multiple scores (affordability index) (Cox and Pavletich, 2013). Although, self-build homes account for a substantial amount CLT SEHM housing delivery with the aim of correcting home ownership imbalances particularly in rural communities in order to maintain affordability (Paterson and Dayson, 2011), this is however a rarity in the urban regions. The East London community land trust is however an exception being the first robust perpetually affordable urban model

with 23 SEHM-based housing units out of 252 dwelling redevelopment (BSHF, 2016). However, with just 0.091% of the project delivered with the CLT SEHM, interest in this model again outstrips its availability and supply, considering the initial appeal it had generated from the target urban community.

In pursuit of these affordability goals, sourcing skilled staff and volunteers is also a challenge for small scale affordable housing developers. One crucial CLT SEHM inefficiency benchmark highlighted by Voith and Watcher (2012) is the detrimental impact on small-scale developers adopting the model of not being able to cope with the lack of substantial resources/funding for, land acquisition/sourcing, management staff for maintenance of housing and common spaces. In comparison to their mainstream counterparts, the housing associations (HAs) usually have paid staff, a committee or board made up of volunteers, representatives from local authorities, business associates, politicians and community groups. This is a strong and influential network rare with typically small and medium scale developers employing the CLT SEHM. Over the past 25 years, the scale and type of companies that deliver new housing in England have undergone significant transitions. However, the resultant delivery structure appears tilted against non-mainstream models, small and medium sized builders (organisations that deliver between 1–500 new houses annually). Moreover, planning permissions for small sites – which are within their construction and administrative capacity – for building projects, are a rarity. Only 8% of all planning permissions in England – between 2007 and 2013 – were issued to housing schemes of less than ten units (20% for London), (Spratt, 2013; South East England Councils, 2017). It is therefore evident that the role of smaller and medium sized house builders in the construction sector has been significantly reduced. As recently as 1995, small and medium sized house builders were responsible for delivering approximately 40% of new housing stock. However, in 2013 they delivered less than a quarter of all new dwellings.

Similarly, in the UK as whole large scale volume house builders dominates housing construction, with approximately half of all new homes developed by just eight organisations (Griffiths and Jeffreys, 2013). This supports the narrative of an increasing number of small and medium sized construction firms/house builders finding it difficult to win public sector work/contracts. They are usually at a disadvantage from the very onset of procurement due to the high level of resources required to fulfil prequalification procedures, questionnaires and tedious documentation processes. Therefore, without dedicated administrative staff and resources, small and medium sized construction firms/house builders may struggle to fulfil these often rigorous and cost intensive criteria (The Federation of Master Builders, 2013).

On land acquisition, large scale dominant house builders are holding sway over large amounts of land in strategic land banks, generally on options agreements – this is a legally binding contract between a landowner and a potential buyer/developer without a planning approval, but still subject to certain conditions being fulfilled (Harrison, 2018). However, this strategy is ‘locking up’ sites in areas with high housing demand far into the future. The result is the potential elimination of competition from smaller house builders and community groups adopting alternative delivery models who cannot access nor afford the cost of land – typically estimated at a ‘reserve value’ of £2,470,000 – in London and £370,000 elsewhere (CPRE, 2015; DCLG, 2015). This scenario hence favours traditional affordable housing supply stakeholder relationships like the HAs and Local Governments, who account for 38% (£37 billion) of all public sector construction

and housing developments (CPRE, 2015). Taking all of these trends into consideration, it becomes apparent that the lack of incentive to address these land acquisition issue for affordable housing development might be partly responsible for the high levels of volatility as suggested by Aubrey (2015).

Budding developments on innovative solutions to this salient problem include the German experience which involves limiting the ‘differences between use value and market value’ among volume developers (CPRE, 2015). In a nutshell, this implies private landowner excesses can be controlled by the imposition of a tax system that regulates profits accrued from hoarded land appreciation. The proceeds from such levies can then be channelled towards public services such as affordable housing (Davis, 2011; Miller, 2013). John Stuart Mill’s social increment theory provides a theoretical justification for this proposal based on the notion that land appreciation is as a result of population influence on growth, as against the investments of individual landowners, for example the modern land banks. Therefore, some of the unregulated profits accrued to land banks can benefit public services in the form of tax increments. Perhaps, this could also serve as tax concessions to developers adopting the CLT SEHM to attain permanent affordability for project beneficiaries.

### *2.1 CLT SEHM Innovation and the role of knowledge management (KM)*

According to Nonaka and Toyama (2005), tacit knowledge involves information built from subjective, almost impalpable and immeasurable experiences logged in the mind/memory and sometimes the subconscious. Moreover, the build-up process graduates through learning, and experiences in an unregimented order. On the other hand, explicit knowledge is much more structured, and developed through articulated and adequate documentation, hence it is tangible. Also, the level of knowledge available concerning the CLT SEHM is tandem to the amount of information not only existing, but also accessible through credible conduits uncensored, i.e., embodying the full scope and potential of the housing delivery model in either or both of tacit and explicit knowledge variations. However, the scope of available knowledge is usually lopsided and sometimes restricted to conventional key indicators and parameters prioritised by policy makers and governmental institutions. This in the long run might be exempting information surrounding alternative housing/property networks, thereby relegating their existence to the fringe of highly restricted portals outside the conduit that drives dominant mainstream housing policies. Also, in situations where they are included, the debate is sometimes misrepresented, hence lack in-depth grasp of how mainstream options could be hampering these alternatives. A recommendation by Paterson and Dayson (2011) includes the improvement of the state of strategic partnership with the aforementioned stakeholders. Developers employing the CLT SEHM are supposed to work in partnership with a variety of stakeholders; like the HA, charities, local authorities and enterprises according to the current structure. For a starter community or developer interested in adopting the CLT SEHM, an interactive functional mesh of stakeholders and a platform for community development networks (CDN) for knowledge transfer, sharing and management will be required to improve these stakeholder networks. Therefore, knowledge cannot be said to have been effective or properly managed/transmitted if innovative models and drivers are not properly understood or embraced by potential beneficiaries and stakeholders across the affordable housing networks.

Liebowitz and Liebowitz (2006) saw KM as the process of creating value from intangible assets such as knowledge and information. Therefore, the quality of knowledge facilitated, shared and maintained is integral to initiating value added change within a sector/organisation. From an affordable housing perspective, it is expected that KM outcomes would drive innovation and problem solving within the stakeholders and community networks utilising the CLT SEHM. To this end, embedded knowledge in individuals if shared efficiently can help establish new routines and mental processes. This helps improve efficiency and the competitive advantage necessary to overcome performance barriers (Krongh et al., 2012; Rana and Goel, 2017). Moreover, it is argued that knowledge sharing generates new ideas which fuel the much needed innovation to effect transformation (Mehrabani and Shajari, 2012). Going forward, the viability of less dominant models with positive attributes would be dependent on researchers' ability to convert vital tacit knowledge embedded in key individuals into explicit knowledge through interaction to drive innovation (Abell and Oxbrow, 2001). Furthermore, the role of targeted information hubs such as CDN, in the context of this study is particularly relevant to the CLT SEHM's unique attribute which is built around its stronger cooperative. Therefore, explicit and tacit knowledge focused on the model's underrepresentation can act as a bridge between trust, social networks, and information surrounding the CLT SEHM necessary to drive innovation and improve its competitive advantage in the UK housing sector. This is further buttressed by Zaqout and Abbas (2012) citing performances in Malaysian universities.

In the UK, according to Miller and Wallace (2013) CDNs are organisations that exist in order to improve the wellbeing, capacity and resilience of communities. If well distributed, CDNs focused on the CLT SEHM could serve as effective KM platforms for a large number of networks in existence across the UK – with varying geographical reach, aims and targets mostly centred on practical advice, support and even lobbying on behalf of stakeholders (communities, housing organisations, professional bodies, individual members and developers interested in the model) – to drive government policies. However, to achieve these goals, the combined effective management of both tacit and explicit knowledge in their resident communities and its translation across the UK policy landscape is crucial to generate competitive advantage for the CLT SEHM. According to Wang and Wang, (2012), managing such knowledge and information from initial creation is considered inefficient until its effective utilisation to achieve significant innovative results. Primarily, the CDN approach to

KM involves the facilitation of discussion/debate (creation), sharing of information and the provision of a better understanding of Community Development in target communities and population. However, it is hard to discern how effective its utilisation has impacted the fate of the CLT SEHM. Judging from the underrepresentation of the model, particularly in urban areas, it appears there is disconnect between tacit knowledge – which might not be in line with government agenda – and the knowledge accepted as implicit by policy makers. Hence, might not be fit for purpose on the long run, i.e., generate the much needed innovation in the UK housing development.

Although previous studies have established the relationship between availability of knowledge and innovation, however, uncovering innovation drivers for affordable housing delivery models and how knowledge (tacit and explicit)/information impacts its perception has not been studied, particularly in relation to the CLT SEHM. Therefore,

this research set out to uncover tacit and explicit knowledge concerning CLT SEHM performance drivers within the study context of (competition in mainstream affordable housing supply) and (funding and CLT SEHM development) as innovation drivers. Furthermore, investigations were carried out on whether the level of knowledge available to housing practitioners influences the aforementioned perceptions on innovation drivers for the CLT SEHM in a competitive affordable housing market.

### 3 Methodology

#### 3.1 Sample and data collection

This aspect of the study aimed to define how competition in the affordable housing market impacts the CLT SEHM within the context of tackling land acquisition finance and CBH isolation in mainstream affordable housing delivery as innovation drivers. According to Newton (2017), due to the intangibility of the creation process of implicit knowledge, developing an understanding could be difficult. Therefore, a qualitative research approach that can help capture narratives and factors necessary to generate intellectual capital comes recommended, as against a quantitative approach where data are forced into algorithms (Demartini and Paoloni, 2013). However, this study combines both qualitative and quantitative methods for rigour, and validity necessary to achieve research goals. To this end, tape recorded anonymous semi-structured interviews were targeted at key representatives of the National Community Land Trust Network (NCLTN) a CDN organisation, academics inclined towards construction housing development, banking and government institution representatives offering loan facilities. Criteria for interviewed key informants include institutions that typically derive their funding from the government and those involved in property mortgage application assessment for (banking institutions). Moreover, an in depth involvement in CLT SEHM development from implementation stages to completion for (community organisations) and active research in sustainable construction and housing development for (built environment academics) were a defining scope for the interview sample. During data collection and preliminary analysis, thematic and theoretical saturation was reached at 14 interviews overall. Data generated were transcribed and subjected to text analysis employing (Nvivo 9.0). See Table 1 showing respondent category codes, enquiry description for both semi-structured interviews and the subsequent questionnaire survey.

**Table 1** Enquiry description

Category (code)	Description/representation/category	Semi-structured interviews	Questionnaire survey	
		No. of responses	No. of questionnaire responses	Key references (Nvivo 9.0)
Industry (I)	Mortgage and housing finance representatives.	6	N/a	39
Community development (CD)	CLT SEHM key enablers from implementation stages to completion.	4		

**Table 1** Enquiry description (continued)

<i>Category (code)</i>	<i>Description/representation/category</i>	<i>Semi-structured interviews</i>	<i>Questionnaire survey</i>	
		<i>No. of responses</i>	<i>No. of questionnaire responses</i>	<i>Key references (Nvivo 9.0)</i>
Academic researchers (AR)	Housing and construction academics with active research in sustainable communities and involvement.	4		
Interest groups	Community networks: to capture nuance and perceptions of representative sample of broad base UK homeowners and seekers interested in community building initiatives.	N/a	91	N/a

## 4 Semi-structured interview and questionnaire results

### 4.1 *Competition in mainstream affordable housing supply*

For the respondents who touched on the impact of implementation policies on the CLT SEHM, the HCA pre-qualification process (PQP) was not seen as a barrier that needed to be resolved; this perception was in constant reoccurrence from respondents respectively.

I: “The function of the PQP is to create necessary checks and balances to regulate affordable housing quality and control land assets; it was not intended to harm anyone apparently.”

Opposing views suggested that the PQP adopted by the HCA might be just too rigorous or rather inappropriate for small builders and aspiring CLT SEHM adopters. Recurrent responses that touch on the issue of procurement and bidding complications revolved around the fact that mainstream providers such as the HAs in collaboration with volume builders have an overwhelming influence in project allocation. This finding supports Lambert (2011) assertion on the overdependence of the industry on HAs. On the contrary, opposing views implied that this is a justifiable situation because of the HA’s well-grounded knowledge base aided by professionals well equipped to manage their portfolios and influence government policies. This confirms literature on the impact of competition on smaller developers in the form of high level of resources required to satisfy pre-qualification criteria. Therefore only volume builders in collaboration with HAs might possess the dedicated funds and administrative staff required to fulfil these requirements (The Federation of Master Builders, 2013). Recommendations on this issue include the need for CLTs to transcend beyond the restricted roles imposed on them due to the effects of competition.

Significant responses on the low mainstream recognition of CLTs suggested that the current arrangements seems to limit CLT SEHM roles to the rural confines; which is underwhelming compared to its potentials on a broader scale. In this regard suggestions included:



CD: “[CLT] innate attributes should give it a competitive advantage over dominant providers in affordable housing supply.”

These areas will include properties or communities in areas subjected to foreclosures, regeneration initiatives or tenure systems that require flexible and low mortgage plans, usually below market rate and an affordability guarantee for subsequent homeowners. These are however residual roles that might not even be playing the field as suggested by responses.

AR: “[This situation]...restricts the roles/niche of the CLT model to a supplementary one, rather than a fairly competitive [...] based on model merits engaging enough to give room for innovation in affordable housing.”

On this issue, alternative responses centred on the need for a realistic assessment of CLT capabilities and scope within the housing industry. These views include the supposed improvement of CLT SEHM applicability as attempts at reinventing the wheel:

I: “Status of HA’s could be viewed as being a social business and the CLT is [just] a movement [that is] attempting to fill up a role that the HAs and more orthodox social systems already occupy.”

#### *4.2 Funding and CLT SEHM development*

Responses concerning the potential options for the communities/developers adopting the CLT SEHM in mitigating land acquisition finance barriers include; acquiring land at agricultural value, taking advantage of Section 106 obligation to provide affordable units in conjunction with a developer and the issuance of community shares to acquire land. General conflicting responses from community organisations did not give much credence to these options given the reason that:

CD: “The CLTs might stand no chance competing with both government and lender backed affordable housing options [such as the HAs...].”

Opinions on the sustainability of both urban and rural asset transfer route for CLTs and land acquisition finance reveal an inefficient knowledge sharing process between concerned stakeholders, because aspiring CLTs usually find it difficult accessing information surrounding land supply (Ayoade and Ahmed, 2014):

AR: “[...] require a deeper understanding on the lack of knowledge existing in councils [and among communities/small builders] on issues surrounding asset [or land] transfer to communities, as it is definitely a viable route CLTs can take advantage of [...]”

This confirms literature on the state of competition with more mainstream models, as this is rarely the case for volume builders adopting tested traditional options because they can afford to train, employ additional staff and procure the necessary knowledge both tacit and explicit (FMB, 2014). Recommendations include the need to support research on best practices needed to get communities sensitised. This is coupled with a viable platform to share bespoke information on viable strategies and information on alternative funding routes and cost reduction strategies for the overall sustainability of the model.

I: “What does and does not work’ in regards to land acquisition/asset transfer and management. [...] ‘without losing focus on the possible limitations of the CLT in regards to maximising community asset ownership benefits [like its documented ability to increase the revenue generating potential of run down properties (Aiken et al., 2008)].”

On the funding arrangement to pursue land acquisition, responses focused on the fact that commercial banks hardly see a need to prioritise the funding of CLT SEHM provision in most of their agenda.

CD: “Maybe a funding source of barrier to CLTs [...] could be more applicable here [...] more of existing structural deficiencies like staircasing restrictions, disadvantage of its attribute which deprives beneficiaries of land ownership [could] limit its [...] among mainstream funders, also making it less attractive to potential buyers that might be interested in the model.”

These restrictions confirm the complicity of the CLT SEHM structure as a limitation to funding as suggested by valid responses;

I: “Getting funding is a major barrier definitely. In the CLT situation; the sales of flats are completely fixed without negotiations [at about 70% of the open market property rate].”

I: “[...] the organisation is able to retain 30% of the flats fixed at perpetuity then retaining the mandate to control the resale price.”

Abandoning these limitations would however imply that housing beneficiaries are allowed to ‘staircase’. This would drastically result in the loss of affordability to the open market. Recommendations include; ruling out the reliance of land gifts and charity grants as sustainable sources for CLT land acquisition funding. It is expected that if the CLT SEHM can acquire land with a considerable cost limiting strategy. This ultimately nullifies the cost in the overall price mechanism of the delivery model. Therefore, eventual beneficiaries will have to acquire the housing without the cost of land. Moreover, the affordable housing developed with this model would not have to sacrifice permanent affordability by giving up staircasing restrictions which is a major issue that appears to be part of distinguishing factors for conventional housing model successes compared to the apparent CLT underrepresentation in the UK. Ultimately, relaxing staircasing restrictions to improve resale profits so as to repay accumulated debts from development costs, particularly land acquisition drastically increases the incentive to ‘flip’ the housing at current market rates. The result is the loss of a once affordable housing to an increasingly volatile open housing market. However, recurrent responses raise the need for the recognition of ethical banks as key financial stakeholders for CLT SEHM suggesting that they can accommodate the limitations of the delivery model. In summary, for the model to be actually competitive, at the same time maintaining permanent affordability to its beneficiaries; more drastic innovation drivers are required which would involve cutting land acquisition costs (Ayoade and Ahmed, 2014). A summary of the findings are expressed in Table 2. The results were extrapolated to develop a questionnaire survey, which was adopted for verification, and to investigate how the level of knowledge inherent in respondents affects their perception of innovation drivers.

**Table 2** Survey perceptions and indicators (distribution)

<i>Variables/dummy variables</i>	<i>Themes and survey indicators</i>	<i>Semi-structured interviews</i>	
		<i>Source</i>	<i>References</i>
P99	Competition in mainstream affordable housing supply	14	22
P99(0)	CLTs are only attempts at reinventing the wheel		
P99(1)	Not sure/lets maintain the status quo (existing state of affairs)		
P99(2)	Tackling CBH isolation in mainstream applicability		
P99(3)	Easing prequalification difficulties accessing funding		
I97	Funding and CLT SEHM development	13	17
I97(0)	CLT roles should be residual/secondary to HAs		
I97(1)	Not sure/lets maintain the status quo (existing state of affairs)		
I97(2)	Addressing CLT limitation and investor preference for HA models		
I97(3)	Tackling land acquisition financing difficulties		

### 4.3 Questionnaire survey

As part of the validation process, results of the interview were developed into a questionnaire. Then invitations for voluntary participation were extended to members of CDN which comprises of community developers, regeneration practitioners and enthusiasts involved with activities concerning homes and assets that are held in perpetuity for community benefit – across urban and rural geographical classifications – such as the CLT SEHM. Questionnaire surveys (149) were electronically distributed (purposive sampling) to this niche group (sample of the UK homeowners and seekers interested in community building initiatives) through the NCLTN online database, community development organisers, asset and cooperative networks with a combined total of over 430 members. A 61.07% return rate was achieved (equivalent to 91 total responses). A random representation of the target networks was sought irrespective of location. This implies that each member of the purposive sample has an equal probability of being selected at random regardless of the location of the respondent within the UK. Hence, this study did not set out to solicit responses based on the location of the potential survey participant. The questionnaire build up comprised of a simple closed and Likert-scale questions. In order to measure respondents' agreements with potential innovation drivers to tackle respective CLT SEHM associated issues, for example 'competition in the mainstream of affordable housing supply': respondents were asked to choose which of the indicators they most agreed with Table 3. Also for the outcome variable on level of CLT SEHM knowledge and information, they were asked a simple yes/no question, if they considered themselves knowledgeable about the CLT SEHM. For this question, 67 respondents considered themselves knowledgeable, while 13 answered otherwise.

### 5 Data analysis and results: binary logistic regression

A logistic regression was performed to ascertain the effects of perception of CLT SEHM innovation drivers on the likelihood that participants are knowledgeable about the CLT SEHM. For more than one independent variables and one categorical dependent variable, the binary logistic regression (multivariate) was considered most appropriate for this study (Field, 2009).

**Table 3** Coding of variables affecting CLT SEHM knowledgeability

<i>Data variable</i>	<i>Data explanation</i>	<i>Data</i>	<i>Codes</i>
Dependent variable	Level of knowledgeability	Binary	0 = no 1 = yes
Knowledgeability	No, yes		
Independent variables	Perception on innovation drivers		
P99	Competition in mainstream affordable housing supply		
P99(0)	CLTs are only attempts at reinventing the wheel	Binary	0 = disagree 1 = agree
P99(1)	Not sure/lets maintain the status quo (existing state of affairs)	Binary	0 = disagree 1 = agree
P99(2)	Tackling CBH isolation in mainstream applicability	Binary	0 = disagree 1 = agree
P99(3)	Easing prequalification difficulties accessing funding	Binary	0 = disagree 1 = agree
197	Funding and CLT SEHM development		
197(0)	CLT roles should be residual/secondary to HAs	Binary	0 = disagree 1 = agree
197(1)	Not sure/lets maintain the status quo (existing state of affairs)	Binary	0 = disagree 1 = agree
197(2)	Tackling land acquisition financing difficulties	Binary	0 = disagree 1 = agree
197(3)	Addressing CLT limitation and investor preference for HA models	Binary	0 = disagree 1 = agree

With the following,  $P$ : probability of  $Y$  occurring,  $e$ : natural logarithm base,  $\beta_0$ : interception at y-axis;  $\beta_1$ : line gradient;  $\beta_n$ : regression coefficient of  $x_n$ ,  $x_1$ : predictor variable,  $x_n$ : predicts the probability of  $Y$ . The analysis was based on the following regression formula:

$$P(Y) = \frac{e(\alpha + \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_nx_n)}{1 + e(\alpha + \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_nx_n)}$$

where  $\alpha$  is a constant and  $\beta_i$  are the regression coefficients for each variable representing CLT SEHM innovation drivers  $X_i$  for  $i = 1, 2, \dots, n$ . Assuming that,  $P(Y) = 1$  or  $0$ , therefore,  $Y = 1$  if the respondent is well knowledgeable about the CLT SEHM and  $Y = 0$ , if respondent is not knowledgeable about the CLT SEHM (Table 3). For the log-likelihood of this baseline model (71.007), this represents the fit of the most basic model to the data, when including only the constant (Table 4).

**Table 4** Log-likelihood of baseline model

<i>Iteration history</i>			
<i>Iteration</i>		<i>-2 log likelihood</i>	<i>Coefficients</i>
			<i>Constant</i>
Step 0	1	71.981	-1.350
	2	71.013	-1.615
	3	71.007	-1.640
	4	71.007	-1.640

Constant is included in the model.

Initial-2 log likelihood: 71.007

Note: Estimation terminated at iteration number 4 because parameter estimates changed by less than 0.001.

Overall the model correctly classifies 83.8% of the respondents. ‘Funding and CLT SEHM development’ variable had the highest Roa’s efficient score, with a score of 22.868 with a significant score below (0.05). Moreover, its inclusion in the model significantly improved the models -2LL from 71.007 to 54.345 by 16.661, i.e., the coefficients for the variables not in the model are significantly different from zero, and therefore the addition of one or more of these variables to the model will significantly improve its predictive power (Field, 2009) (Table 5).

**Table 5** Difference between the coefficients of the variables not in the model

<i>Model if term removed</i>					
<i>Variable</i>		<i>Model log likelihood</i>	<i>Change in -2 log likelihood</i>	<i>Df</i>	<i>Sig. of the change</i>
Step 1	P99	-35.503	16.661	3	0.001
Step 2	I97	-27.173	10.148	3	0.017
	P99	-26.994	9.790	3	0.020

The omnibus tests of model coefficients was significant (chi square 16.661, df = 3,  $p < 0.01$ ) (Table 6). Therefore, the new model is better at predicting whether someone was knowledgeable about the CLT SEHM with the inclusion of the ‘Funding and CLT SEHM development’ variable, hence confirming the pivotal role of addressing this issue as an innovation driver (by explaining more of the variance in the outcome).

**Table 6** Omnibus tests of model coefficients

<i>Omnibus tests of model coefficients</i>				
		<i>Chi-square</i>	<i>df</i>	<i>Sig.</i>
Step 1	Step	16.661	3	0.001
	Block	16.661	3	0.001
	Model	16.661	3	0.001
Step 2	Step	10.148	3	0.017
	Block	26.809	6	0.000
	Model	26.809	6	0.000

The Cox and Snell and the Nagelkerke  $R^2$  were adopted for the coefficient of determination ( $R^2$ ). This study recorded 0.285 and 0.484, respectively. The maximum value that the Cox and Snell  $R^2$  attains is less than 1. However, the Nagelkerke  $R^2$  is an adjusted version of the Cox and Snell  $R^2$  and covers the full range from 0 to 1. It is therefore considered more reliable. The  $R^2$  statistics can be referred to as effect size which validates the suitability of the study’s construct in predicting the response variable (Bewick et al., 2005). The value of 0.484 (see below) indicates that the model is useful in predicting CLT SEHM knowledgeability. Where  $L(M_{intercept})$  = value of the likelihood function for the model with no predictors, and  $L(M_{full})$  = likelihood for the model being estimated, and;  $N$  = sample size (Cox and Snell, 1989; Nagelkerke, 1991; Menard, 2000; Long and Freese, 2006).

$$R_{cs}^2 = 1 - \left[ \frac{L(M_{intercept})}{L(M_{Full})} \right]^{\frac{2}{N}}$$

$$R_{cs}^2 = 0.285$$

When  $L(M_{full}) = 1$ , then  $R_n^2 = 1$ , when  $L(M_{full}) = L(M_{intercept})$ , then  $R_n^2 = 0$ .

$$R_n^2 = \frac{1 - \left[ \frac{L(M_{intercept})}{1 - L(M_{Full})} \right]^{\frac{2}{N}}}{1 - L(M_{intercept})^{\frac{2}{N}}}$$

$$R_n^2 = 0.484$$

Therefore, the effect size (pseudo  $R^2$ ) as indicated by the ‘Cox and Snell’ and ‘Nagelkerke’ test (Table 7) indicated that the binary logistic regression equation for the full model has a good predictive power. ( $R_{cs}^2 = 0.285$ ,  $R_n^2 = 0.484$ ). This was buttressed by the reduction in  $-2 \log$  likelihood ( $-2LL$ ) when subject variables are included; hence the amount of the unexplained variance has been reduced.

**Table 7** Model fitness and effect size indicators

Step	$-2 \log$ likelihood	Cox and Snell R square	Nagelkerke R square
1	54.345	0.188	0.320
2	44.197	0.285	0.484

### 5.1 Binary logistic regression results

From the significant contributing factors that influence CLT knowledgeability we can fit the logistic regression model as:

$$P(Y) = \frac{e^{(-3.958+0.574x_1+0.529x_2+\dots+\beta_nx_n)}}{1 + e^{(-3.958+0.574x_1+0.529x_2+\dots+\beta_nx_n)}}$$

This regression model indicated a large exp (B) upper value of 68.059, for the I97 (3) variable: ‘Addressing CLT limitation and investor preference for HA models’. This can be attributed to this particular variable having a narrow distribution within an uncommon category. Perhaps, this would not be evident/occur in a larger sample size, but according

to Greenland et al. (2000) it can and does occur in large datasets. Removing this variable from the model through adjustments/penalisations could in fact exacerbate the otherwise acceptable model fit indices – as explored in preceding sections – for this study, or worsen bias in ratio estimates by the loss of important confounders from the regression (Greenland et al., 2016). However, this variable was not significant  $p > 0.05$ , hence not reported in the study’s findings; it appears to almost perfectly predict CLT SEHM knowledgeability.

**Table 8** Summary of binary logistic regression predictions for CLT SEHM knowledge and innovation drivers’ perceptions

		<i>Variables in the equation</i>					<i>95% C.I. for EXP(B)</i>		
		<i>B</i>	<i>S.E.</i>	<i>Wald</i>	<i>df</i>	<i>Sig.</i>	<i>Exp(B)</i>	<i>Lower</i>	<i>Upper</i>
Step 1 <sup>a</sup>	P99			13.473	3	0.004			
	P99(1)	1.274	0.337	14.292	1	0.810	3.575	0.613	1.935
	P99(2)	0.544	0.136	15.773	1	0.000	1.723	0.277	0.811
	P99(3)	0.501	0.810	0.382	1	0.536	1.650	0.337	8.071
	Constant ( $\alpha$ )	-2.398	0.522	21.083	1	0.000	0.091		
Step 2 <sup>b</sup>	I97			8.360	3	0.039			
	I97(1)	1.338	0.460	8.461	1	0.904	3.811	0.436	2.239.
	I97(2)	0.574	0.273	4.420	1	0.017	1.775	0.039	1.071
	I97(3)	1.427	0.910	1.002	1	0.317	4.166	0.255	68.059
	P99			7.491	3	0.058			
	P99(1)	1.271	0.412	9.517	1	0.614	3.564	0.463	2.078
	P99(2)	0.529	0.248	4.550	1	0.008	1.697	0.043	1.015
	P99(3)	-0.012	0.910	0.000	1	0.989	0.988	0.166	5.881
	Constant ( $\alpha$ )	-3.958	0.423	7.739	1	0.005	0.019		

Notes: a – variable(s) entered on step 1: P99, b – variable(s) entered on step 2: I97.

$R^2 = 0.8$  (Hosmer and Lemeshow, 0.285 (Cox and Snell), 0.484 (Nagelkerke).

Model  $\chi^2 (2) = 26.809, p < 0.05$ .

Overall, this model passed all model fitness indicators (effect size, ‘Cox and Snell’, Hosmer and Lemeshow and ‘Nagelkerke’ tests). This is an indication that the binary logistic regression equation for the full model is suitable and has an acceptable predictive power for the study’s datasets.

From the odds prediction equation:  $[odds = e^{\alpha + \beta x}]$ , if a respondent agrees that ‘Tackling CBH isolation in mainstream applicability, is an innovation driver [P99 (2) = 1], the odds of being knowledgeable about the CLT SEHM is:  $[odds = e^{-3.985 + 0.529 (1)} = 0.032]$ ; also if a respondent disagrees that ‘Tackling CBH isolation in mainstream applicability, is an innovation driver [P99 (2) = 0], the odds of being knowledgeable about the CLT SEHM is:  $[odds = e^{-3.985 + 0.529 (0)} = 0.019]$ . For this innovation driver, in order to generate the odd ratio predictions for the model, i.e., Exp (B) was computed as follows:  $e^{\wedge (b_0 + \beta_1)} / e^{\wedge \beta_0} = 1.69$ . See (Table 8), for the remaining results.

According to the binary logistic regression model, the need to ‘tackle CBH isolation in mainstream applicability’ and solving ‘land acquisition finance difficulties’ as an innovation driver in a competitive affordable housing market point of view are powerful predictors of how knowledgeable the respondents are about the CLT SEHM. In summary, a respondent who considers tackling ‘CBH isolation in mainstream applicability’ as an innovation driver for the CLT SEHM is 1.69 times more likely to be knowledgeable about the CLT SEHM. In the same context, a respondent who considers solving ‘land acquisition finance difficulties’ as an innovation driver for the CLT SEHM has a 1.77 times chance of being knowledgeable about the CLT SEHM.

## **6 Discussions and conclusions**

From this study’s perspective, findings suggest high odds ratio for significant innovation drivers assessed. This is however not unusual, considering the study sample’s general inclination towards, housing and community development. To this effect, this study demonstrates how much impact knowledgeability can have on perception of innovation drivers for the CLT SEHM. Strategically, this could imply that the susceptibility of policy makers or communities to support sustainable affordable housing delivery models can be greatly influenced by the level of model specific knowledge that is available to potential beneficiaries and stakeholders as a whole.

In the supply chain, alternative delivery models, small builders and developers can be considered most affected by land acquisition difficulties posed by the actions of volume and large scale builders, sometimes in collaboration with preferred partners such as large HAs. Alternative models are therefore isolated from mainstream affordable housing delivery or relegated to residual adoption outside mainstream applicability. This point segues into the other significant predictor of CLT SEHM knowledge, i.e., the need to tackle CLT SEHM isolation in mainstream affordable housing delivery. This finding confirms literature on the dominance of HA models over alternatives. As a recommendation, innovation drivers centred on tackling issues stemming from the fallouts of a lopsided competitive housing market can be anchored by efficient knowledge dissemination. Furthermore, research aimed at developing frameworks to either challenge or surmount unfair land acquisition structures can be encouraged by policymakers. Considerations include increased lobbying for housing tax concessions/credits on land acquisition for small developers/builders adopting the CLT SEHM holistically, hence preserving the permanent affordability component/attribute. This in turn can help justify the need for increased institutional and political support for true diversity in housing delivery models as a means to tackle isolation of the CLT SEHM, at the same time improve the affordable housing deficit.

On the problem of supposed land ‘hoarding’ by volume builders for unbridled profits, innovative solutions as operated in Germany can be adopted and modified to fit into the UK’s experience. This approach appears to have helped keep Germany’s affordable housing market considerably less volatile than the UK. Adopting this concept will involve the freezing of land values upon its designation for affordable housing through alternative delivery models. Upon acquisition/allocation at existing land use value (either to small builders, the community or the local authorities), any further open market appreciation ensuing from its sale to less sustainable mainstream developers including high end developments would be channelled towards subsidising/cutting housing cost



below the open market rate (Aubrey, 2015). This could also be implemented in the form of tax concessions to small and medium scale builders employing the CLT SEHM in collaboration with local councils as long as a significant percentage of the development remain permanently affordable. This innovation, when coupled with delivery through the CLT SEHM and the employment of cost saving modern methods of construction by small builders further improves project cost efficiency and permanent affordability. Perhaps this could help close the feasibility gap between ‘Addressing CLT limitation and (limiting) Investor preference for HA models’.

In order to improve knowledge transfer implications for the adoption of innovation drivers in affordable housing, it is of utmost importance to address what appear to be systemic inefficient knowledge transfer practices within stakeholders’ networks. Moreover, in procurement the role of knowledge cannot be overemphasised as prequalification procedures can be extremely knowledge and resource intensive particularly for small scale builders or communities intending to adopt the CLT SEHM for housing delivery. For the larger community, in a bid to bolster support for less familiar housing delivery models, being knowledgeable about the model should help improve its acceptability. The policy implications for knowledge and innovation considering the present arrangement include the need to encourage the dissemination of successful best practices among a strong network of concerned stakeholders. This strategy would require the funding of proactive enabling platforms such as knowledge sharing avenues for information replication and the facilitation of research among small builders/developers in areas where housing needs are established. It is expected that this would help raise awareness on CLT SEHM associated issues and the mitigating role of innovation drivers.

In summary, improving knowledge sharing among small scale builders and target communities, which are viable adopters of the CLT SEHM, is deemed crucial. For viable innovation drivers, the study’s findings demonstrated a possible pathway towards expediting consensus in stakeholder interaction, engagement and policy making. It is remarkable how much impact CLT SEHM knowledgeability can have on being able to cut through assumptions, generalisations, hence bridge the disconnect between tacit knowledge – which might not be in line with government agenda – and the knowledge accepted as implicit by policy makers. As those with ‘knowledge’ have clear views on specific innovative positions on what should change (within the study context) across the UK policy landscape.

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