



Individuality Included

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Abstract

Only a few percent of new detached houses in Finland are designed by architects. Most people planning to build a house use only free design services included in the price of house delivery. This means for example that a building engineer designs the house based on some standard model, which he changes according to discussions between sales person and customer. This often results in seemingly generic houses that do not capture most value of the plot. Log houses make no exception in the Finnish market, even if they are a somewhat luxury product abroad. Why do not people in Finland use architects for designing their log houses? Is it because of the price of the design work? How does the log manufacturer's system of configuring houses work without architects? Are log house companies satisfied with the current system? Could mass customization strategies be suitable for developing design and production processes of log houses?

This paper presents results of studying the need and supply of individuality of log houses, and current house design processes that let users participate configuring their new log homes in Finland. The study was carried out via consumer study and interviews of log house industry's managing directors and sales personnel. All of these companies are building non-speculative individually-commissioned houses, building houses to meet customers' individual orders rather than for stock.

Based on our consumer study, there is a great demand for individual houses. Only 8,8% of the consumers would choose a standard house model. However only 10% of respondents would prefer a unique house designed by an architect, while 68.9% would prefer a modified standard model. Most important reason for not using architect is the price of the design work. This results in contradiction, since consumers want an individual house, but are not ready to pay for designing.

Surprisingly, all interviewed managing directors of log house companies said they produce only individual houses. Customers always want some modifications even in the standard models, and that results in designing each house anew. This has a negative effect on the profits of the companies, since design work is included in the price of the house delivery. What customers might not realize is that when design work is done at the risk of house builders or even sales people, it is done with as little effort and cost as possible.

Since the existing design process of log houses produces often seemingly generic but always laboriously planned houses, there would be need for improvement. Systematization of individual choices could benefit log house companies in terms of design resources. And If mass customization approach would bring architectural quality available to a broader group of new log house dwellers, they would benefit, too.

Keywords: mass customization, log house, wood architecture, individuality, design process, affordable housing, affordable individuality

Introduction

Building a house of one's own is often a big dream come true, and a heavy financial effort to most people. This biggest investment of a life-time is however often executed as a seemingly generic standard house model whose designer might even never have visited the building site. In an extreme situation there might be a great plot by the river and a dream house chosen from the house manufacturer's catalogue, resulting in a house where only one window faces the river view.

In order to make the most of a plot and fulfill the needs of the customer, individual design is required. However automation of design (Duarte and Simondetti 2002) is still utopia. Design work of individual or tailored homes is laborious.

Finnish log house manufacturers- and also other house manufacturers - provide design services included in the price of the house delivery. Customers have learned that they only have to pay, if they in the end order the house delivery. In some log house companies even more than half of the staff might be engaged in design work.

An architect might think that using the help of architects would be the obvious solution for designing an individual house that fullfills the needs of the dwellers and fits the site best. However, there is a considerable marketing pressure of house manufacturing companies' seemingly easy and "free" services. And at the same time there is absolutely no marketing pressure from architects willing to design low budget houses. It is hard for architects to compete with seemingly free services, so there are not many who would try. While best architectural quality and value for money might be reached via using an architect and hiring good constructors, it demands a customer to take a more active role in various stages of the design and building process of the house. Uncertainty of building costs is also greater when compared to house manufacturer's services.

There will always be room and need for individual houses designed by architects. However, there is also need for developing complimentary design services of house manufacturing companies. Aim of this development should be in adding architectural quality and at the same time systematizing and thus streamlining the design process.

Mass customization in housing is a process optimization strategy which aims at providing individuality for the price of mass production. For example according to Noguchi (2001), mass custom design approach, in which housing products and services are well standardized and integrated into the system, may have the great potential to reform the current housing delivery system and contribute

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towards producing good quality affordable homes that corresponds with today's market demands for housing—i.e. affordability and customizability. (Noguchi 2001). According to him, mass customization aims at combining individuality with affordability.

When developing and designing mass custom housing there are many aspects to consider. Systematization of individual choices is the key. Customer interface, manufacturing systems and supply chain management must all be taken into account.

When developing a mass custom housing model, house design and customer interface should work seamlessly together with production processes. Mass customizers allways need to develop a mechanism that elicits and reveals individual customer needs and transforms these needs into suitable products (Zipkin, 2001).

Out of all these aspects arise following research question: Could adopting mass customization approach benefit both finnish log house manufacturers and future log house dwellers?

This study is part of Modern Log City research program and its preliminary study phase in Oulu School of Architecture. The project aims at studying new log architecture within cities, use of mass customization and life-cycle economy of log buildings.

Theoretical background

Mass customization in housing is in this paper understood as a process optimization strategy which aims at providing individuality for the price of mass production. This idealized state might never be fully reached, but mass customization can still be used as a strategic mechanism, and a process for aligning an organization with its customer's needs. (Salvador et al 2009) This will over time supplement and enrich an existing business.

According to Salvador et al, mass customization requires a business to develop three fundamental capabilities: 1.) The ability to identify the product attributes along which customer needs diverge 2.) The ability to reuse or recombine existing organizational and value-chain resources to fulfill a stream of differentiated customer needs 3.) The ability to help customers identify or build solutions to their own needs while minimizing complexity and the burden of choice.

Mass customization should not be seen as a stand-alone business strategy for replacing old processes, but as a set of enriching organizational capabilities. Zipkin has argued for three capabilities of mass customization systems: 1.) Elicitation is a mechanism for interacting with the customer and obtaining specific information. 2.) Process flexibility means having the technology to fabricate the product according to the information and 3.) Logistics is distribution of right items to right customers.

For a mass custom system to work, these three must be linked tightly to form a coherent, integrated whole. Mass customization systems cross traditional organizational boundaries, particularly those between sales and production. Companies must have organizational agility in addition to technical agility to enable co-operation across the boundaries.

Elicitation is essential and difficult. Customers are easily overwhelmed by too many selections. Deeper levels of customization often require an elaborated enabling mechanism, sometimes called a configurator. Mass customization needs several kinds of elicited information. Typically there is the need for

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physical measurements, customer's selections from alternatives and reactions to prototypes. In architecture, 3D prototypes can be used.

According to Zipkin, potential for mass customization can be seen in products where customers differ sharply in their preferences for certain product, and in products that are already on the market in customized (not mass customized) versions. Zipkin warns that mass customization has its limits. Several elements have to work well to make mass customization a plausible business strategy. There are also other ways to create variety. For example adjustable car seats make individual customization of car seats unnecessary.

Theories mentioned above originate from the business sector. Theories of mass customization in the context of housing (Barlow and Ozaki 2003, Noguchi 2000, Zipkin 2001) stress the importance of developing communication techniques that let users systematically participate in designing their new home. Mechanistic by nature, they aim at systematization of complex communicative processes.

According to Noguchi (2000), mass customization system can be described as a conceptual model of $MC = f(PS)$. In this model, the 'service sub-system' (S) concerns communication techniques that lead users to directly participate in customizing their new home. 'Product sub-system' (P) covers production techniques to encourage housing suppliers to mass-produce housing components.

Further Barlow and Ozaki (2001) describe Japanese lessons on customer focused housebuilding. Big Japanese house builders have concentrated their competitive strategies on three aspects: on their production processes, focusing on 1.) Supply chain management and 2.) Manufacturing systems, and 3.) The customer interface. The approach to manufacturing homes, including standardization of components and subsystems, has enabled them to offer high levels of customization.

So depending on theoreticians, processes that let users participate configuring their homes are called "Customer interface" (Barlow and Ozaki 2003) or "Service sub system (S)" (Noguchi 2000) or "Elicitation" (Zipkin 2001).

In mass customization, optimization of the production process is directed by "pull", the clients' wishes. (Cuperus et al 2003) Houses are built to meet customers' individual orders rather than speculatively for stock. Simply put, the term "pull strategy" means production according to individual orders. The opposite of this would be "push strategy" which in housing would mean building housing developments speculatively and selling them to customers as turnkey products.

Masa Noguchi has proposed a choice model for the delivery of mass custom homes. (Noguchi, 2004) The main purpose of the choice model is to systematize a decision making process for the selection of alternatives that helps mass customizing an end product, such as a housing unit or development.

In order to mass customize an end product, there are five stages within the choice model that may need to be followed cyclically.

1. Identification of need: Homebuilders build homes that need to meet the market demands. Identify local market demands for housing.
2. Formulating of industry's objectives and specifications: Identify industry's wishes, variables and concerns that will be taken into consideration. Task related variables focus on the "economic" choice, and they can be for example with regard to the cost, quality and time factors. Non task variables generally concern the "emotional" factors. This stage serves to establish evaluation criteria including both task-

- and non task related concerns, so that the alternatives generated in the next phases can be evaluated.
3. Generation of alternatives: After the multiple evaluation criteria are established, a set of alternatives will be generated. These alternatives – combination of products and services - contribute towards mass customizing an end product that corresponds to market stimuli. The combination of existing or standardized elements helps make the end product mass customized.
 4. Evaluation of alternatives: The value of the alternatives formed in the preceding stage will be analyzed in terms of the task- and non-task related concerns. The choice model for mass customization focuses on analyzing the value that represents not only the cost of the products or services in question, but also the industry's needs, desires and expectations.
 5. Selection and visualization of alternatives: The "value visualization" helps the industry make the final decision for the selection of the preferred alternatives, in response to market stimuli.

Any research of mass customization in the context of log house architecture is not known to our research group.

Research process

As part of the Modern Log City research program, this paper presents results of the parts of the research dealing with demand and supply of individuality and current processes that let users participate in designing their new homes. Three parts of the research were relevant from this viewpoint: consumer study, interviews of log house industry's managing directors and interviews of salespeople.

Consumer study was carried out via an electric survey using Google Forms. A link to the questionnaire could be found on the home page of eight log house companies based in northern Finland from April to June 2016. The language of the questionnaire was Finnish and the target group local. It was also possible to fill a paper questionnaire in a construction fair in Oulu in April 2016. These answers were added to Google Forms later.

The questionnaire was divided in 9 parts. First part dealt with basic information of the respondent and last part was for personal information if interested in participating a lottery. Other seven parts were questions regarding the appearance, qualities, experience, ideas, planning and buying a log house. Both open long text answers and scale ratings were used. Respondents were for example asked how they would prefer their house to be designed and what kind of site and budget they had.

It took about ten minutes to answer the questionnaire. We got 256 answers, which was big enough sampling for this research. Most consumers answered all questions, but some only part of them. Answers were automatically updated in Google Forms, which also created diagrams for the analysis.

Industry's experiences, needs and expectations were first studied by semi-structured face to face -interviews to managing directors of eight log house companies based in northern Finland, all participators of Modern Log City – research program. All of these companies build non-speculative individually-commissioned houses, building houses to meet customers' individual orders rather than for stock.

Interviews proceeded following a questionnaire, but the interviewer asked also further questions during interview. These interviews took between 60-120 minutes, and they were recorded and transcribed. Questions were not shown to the interviewees in advance.

Managing directors were further asked to suggest each 1-2 salespeople to be interviewed. Seven of them were chosen from different locations: Helsinki, Kuopio, Oulu and Tampere in Finland and one who sold Finnish log houses in Germany. Semi structured face to face interviews were carried out also with them following a questionnaire, but the interviewer asked also further questions during interview. These interviews took between 60-120 minutes, and they were recorded and transcribed. Questions were not shown to the interviewees in advance. All of the interviewed salespeople were independent entrepreneurs who sold log houses on sales commission basis.

Questions to managing directors and salespeople dealt with individuality, design processes, flexibility, architectural quality, market potential and possibilities of mass customization.

Managing directors were asked to express their views about individuality, serial production and architectural quality also graphically. (Figure 1) Individual house on the left and serially produced house on the right, they were asked to mark A) their production focus at the moment, B) best choice for fulfilling the needs of the customer, C) best choice in terms of architectural quality, D) best choice in terms of flexibility of the floor plan and E) best choice in terms of market potential.



Figure 1. Managing directors were asked to express their views also graphically. Individual house on the left and serially produced house on the right, they were asked to mark A) their production focus at the moment, B) best choice for fulfilling the needs of the customer, C) best choice in terms of architectural quality, D) best choice in terms of flexibility of the floor plan and E) best choice in terms of market potential.

Merkittäviä yllä olevalle janelle kirjaimet likimain siihen kohti, joka mielestänne täyttää parhaiten seuraavat tavoitteet. Mikäli alue on leveä, voitte liittää jokaisen kirjaimen alle viivan kuvastamaan alueen laajuutta.

- A) Tehtaanne tuotanto painottuu (kirjain) ja kattaa (mahdollinen jana) tällä hetkellä.
 B) Edustaa asiakkaan tarpeet täyttävän suunnittelun kannalta parasta vaihtoehtoa
 C) Edustaa arkkitehtuurin laadun kannalta parasta vaihtoehtoa
 D) Edustaa pohjaratkaisun joustavuuden kannalta parasta vaihtoehtoa
 E) Edustaa markkinaisuuden kasvattamisen kannalta potentiaalisinta yksilöllisyyden astetta (toisin sanoen missä uskotte olevan kysynnän painopisteen (kirjain) ja miten laajaa (mahdollinen jana) uskotte sen olevan tulevaisuudessa)

Huomioita ja kommentteja:

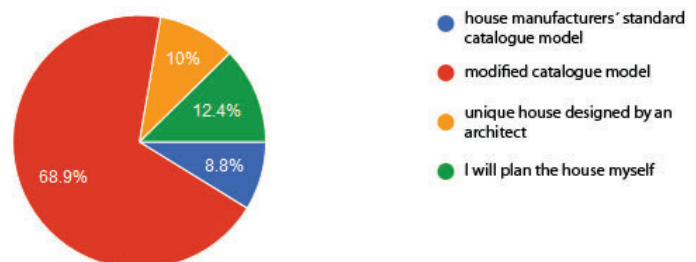
Results

Based on the consumer survey, there is a great demand for individual houses. (Figure 2) 91,2% of the consumers want individuality, since only 8,8% of them would choose a standard house model. However only 10% of the consumers would prefer a completely unique house designed by an architect, while 68.9% would prefer a modified standard model.

Figure 2. Customer demand for individual houses. 68.9% of customers would prefer a modified standard model.

If You would build a log house, which of the following would fulfill Your needs?

(251 responses)



Also all eight interviewed managing directors said their company produces only individual houses (A). Customers always want some modifications even in the standard models, and that results in designing each house almost from the scratch.

According to salespeople, demand for individuality can be explained by some key features. These are the attributes along which customer needs diverse (Salvador et al 2009). Log houses are nowadays built on many different kinds of plots varying from countryside locations to densely built urban environments. Varying plots have different conditions, landscapes and building regulations. Especially most densely built areas around Helsinki and Tampere have small plots and strict demands for appearance.

Budgets vary and set different limits each time. It is also important to make customers feel like the house has been tailored for the individual needs and tastes. Many interviewees also said that fulfilling individual needs of the customers is the most important criteria of architectural quality.

Even though automation of production process enables easy production of almost any kind of log architecture, design work of individual or tailored homes takes lot of resources. In some companies even more than half of the staff might be engaged in design work. This has a negative effect on the profits of the companies, since design work is often included in the price of the house delivery. Customers are not used to pay for individual design, they expect to get an individual house at the same price as a standard model.

This phenomenon is especially problematic for log house builders, since they often only sell the log frame and wooden parts of the house, but end up designing all the bathrooms and saunas as well – for free and not being sure if all the work will get paid at all. Another company might give a lower priced offer for the house plans made by their competitor. Or the customer might not have enough money to build, after all. Several managing directors discussed the free design work done even by 3-4 competitors simultaneously.

Most important reason for not using architect is the assumed high price of the design work. This results in contradiction, since consumers want an individual house, but are not ready to pay for the design work. When consumers were asked reasons for not using architect, high price was mentioned in 60 % of the answers and it appears to be clearly the most significant reason. 16% said there are enough ready, modifiable models and 10% said they were capable and willing to plan themselves. Only 6% mentioned some prejudices such as architects designing only for themselves and not the client, and their structural solutions being expensive or not lasting.

All interviewed managing directors of log house companies said they produce only individual houses. Customers always want some modifications even in the standard models, and that results in designing each house anew.

House budgets of the respondents are low. 41,4% of the respondents had a budget of less than 200 000 and 42,1% of less than 300 000 euros. The average cost of new houses for example in Oulu in 2016 being 280 000 euros (Kviik 2017), it can be said that at least half of the customers had unrealistically low budgets. Even if hiring an architect would not cost much, with an unrealistically low budget you need to cut every cost you can somehow avoid.

Most log houses in Finland seem to be designed quite reluctantly and with as little effort and cost as possible, since the work is done at the financial risk of the log house builders or even sales people. And since the design work is done at own risk, it is in most cases not an architect- an expensive professional – doing the work. As one managing director put it: “A Finn will do even with inferior as long it is free.”

Managing directors would in principle wish to either get customers pay for the planning work via design deals, or just simply get the customers come to them with ready drawings. On the other hand this is not the whole truth: Guiding interested customers to some free designers can be a risk of losing the deal, since sovereign plans can be used to get competing offers from others. Offering

individual plans included in the price is a competitive strategy. In times of economic boom builders can focus on repetitive production while in low economy individuality is offered more generously.

Current design processes

Many interviewed representatives of log house companies stressed the importance of the site. However, they had different views on how common it was to visit the building site during design. Based on our research material it seems that in most cases some professional – salesperson or designer – does visit the site.

Roughly categorized, architects are often part of the design processes in Helsinki, Vantaa, Espoo and Tampere, all densely built urban areas in southern Finland. There it is difficult to handle the complicated bureaucracy of building permits without architects. In rural areas and smaller towns design processes are led by salespeople, whose education vary from social worker to business. Most often salespeople do not have any education from the building sector. “You have to have some psychological eye”, explained one managing director.

Sketches are done either by the sketch service of the log company, by salespeople or their contact –in one case even by the daughter of the sales representative –or by architect. To lower the design costs, some salespeople took care of the site visits and customer meetings themselves and architects’ design work based on memos and pictures. Some companies had had for example trade show campaigns where they had offered architect service for free and architect had done 5 house design as a kind of serial design work: Visiting sites and meeting customers at once in the same area.

According to salespeople, best collaborative design processes with architects include economical and structural evaluation of architects’ designs done by the log house company already in the sketching phase. Salespeople saw a need to develop collaboration processes between architects and log house builders. They preferred to do this by developing collaboration with same architectural offices.

When architect is not part of the design process, designing is usually done by modifying standard models. Unmodified standard models are used only when budget is very low and site sets little limits. Standard models are still important for catching interest of customers and since they show what for example 150m² is enough for.

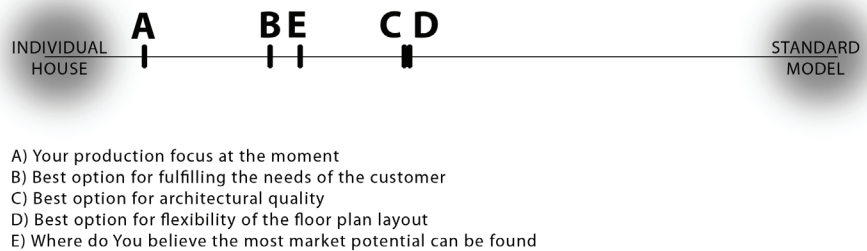
Best models have been refined via repetition and feedback, and they have a strong character and some recognizable features that stay recognizable even when making big changes in size and layout. Common changes are for example mirroring floor plan or making the model fit the site in some other way, changing log types, changing style between modern and traditional, adding or removing rooms and dividing walls, changing room sizes and changing window positions, sizes and colors. Interior decoration of kitchen and bathrooms are usually not part of the log house delivery, but their floor plans are drawn and they are one big design theme that causes changes in layout. Changes to the standard models are often considerable. Customers might, for example, wish to combine floor plan of one model with the exterior of another model and roofing structures of a third model.

Since modifying standard models is the most common way of designing a log house, mass customization as a product development and customer participation strategy would seem to suit log houses well. From the view point of log house builders, more repetition in design – not so much in fully automated production - is seen as desirable.

Interestingly, all managing directors believe that a move in the direction of developing some standardization would increase architectural quality (C) and

flexibility of the floor plan (D), be the better solution for fulfilling needs of the customer (B) and grow the market potential (E). The summary of the markings of all managing directors can be found below. (Figure 3)

Figure 3. Summary of the markings of all interviewed managing directors. All eight interviewed managing directors said their company produces only individual houses.



However only few representatives of log house builders had heard of mass customization. When discussing this theme, most managing directors said they saw potential worth testing in developing ideas of mass customization further in their industry. Only one said log is primitive and tailorable by nature, and mass customization would not benefit log industry.

Some mass customization solutions are actually already in use. Some companies use garage- and bay window modules. They also provide same models as both traditional and modern versions and with different corner designs for different kinds of logs.

Interviewees suggested possibilities of developing more repetition in designs. Since most expensive spaces are in the kitchen and bathrooms, some limited choice of bathrooms would have cost-lowering effect. It was also suggested that technical spaces or even walls could be produced as modules.

It is important to give customers a feeling of tailoring for the individual needs and taste, but according to our interviews, this does not necessarily have to mean enormous changes. The feeling of getting an individual house designed just for You is important, even if small changes in floor plan and facades could be enough.

Conclusions

This paper presented results of studying demand and supply of individual log houses in Finland. The aim was to find out whether adopting mass customization approach could benefit both Finnish log house manufacturers and future log house dwellers. The research was carried out via consumer study and interviews with log house industry's managing directors and sales personnel.

From the consumer study we found out that 91,2% of the consumers want individuality. Only 8,8% of them would choose a standard house model. However only 10% of consumers would hire an architect, since they do not want to pay for design work. Finnish customers have learned to use the "free" design services included in the house delivery, and that they only have to pay if they in the end order the house delivery. Customers want an individual house for the same price as standard model.

When design work is done at the financial risk of house builders, it is done with as little effort and cost as possible. This results in risks about the quality of the design. If adopting mass customization approach could improve architectural quality of the houses, future log home dwellers would benefit greatly.

This paper also explored log house industry's views about individuality, serial production and architectural quality of housing. All interviewed managing

directors of log house companies said that they produce only individual houses. Varying plots, budgets, families and needs set different requirements each time. Everybody wants to get the feeling of individuality. Offering individual plans included in the price is a competitive strategy. In times of economic boom builders can focus on repetitive production while in low economy individuality is offered more generously.

However log house companies are unsatisfied with the current system. Even though automation of production process enables easy production of almost any kind of log architecture, the design of individual or tailored homes is laborious. This has a negative effect on the profits of the companies, since design work is often included in the price of the house delivery.

In some companies even more than half of the staff might be engaged in design work. Finding skilled staff for design is even the bottleneck of growth in many log companies.

Managing directors expressed interest in finding mass customization solutions that would combine benefits in terms of design resources, production costs and architectural quality. Systematization of making individual choices could benefit log house companies in terms of design resources, if adopting mass customization principles would streamline the design process.

In the light of mass customization theories and this research, mass customization strategies could be suitable for developing design and production processes of log houses. Potential for mass customization can be seen in products where customers differ sharply in their preferences for certain product, and in products that are already on the market in customized (not mass customized) versions (Zipkin 2001). In log house architecture there is a great demand for individuality, and customers differ sharply in their preferences for housing products. Varying plots, budgets, families and tastes set different requirements for each house. All interviewed managing directors of log house companies said they produce only individual houses. Customers always want some modifications even in the standard models, and that results in planning each house anew. Process flexibility (Zipkin 2001) is already well developed thanks to automation of production, and Logistics will not be a problem for delivering houses to right customers. What remains critical is Elicitation, developing an elaborated enabling mechanism or configurator that let users participate in configuring their new log houses. This requires developing cooperation and crossing boundaries between sales and production. Easy to use web application for configuring a log house would seem to be desired by at least one of the participating log firms.

Since modifying standard models is the most common way of designing a log house, mass customization as a product development and customer participation strategy would seem to suit log house companies well. Mass Customization theories often describe a movement from mass production to more customization. However from the view point of log house builders, more repetition in design – not so much in fully automated production - is seen desirable. Since now in 2017 is a time of building boom in Finland, time should be right for developing mass customization strategies. However affordability and feeling of individuality must be combined, in order to meet customer demands.

Using mass customization as a strategic mechanism would benefit both log house companies and future residents since they help develop affordable housing products that meet the demand, and bring architectural quality available to broader group of residents.

What remains critical is systematization and control over the process of making customer choices. Mass customization should lighten the design work, not add to it. Providing high levels of customer service and choice over design can be

resource-intensive. (Barlow and Ozaki 2001). Mass customization also requires developing tight co-operation between sales, production and design. Configuring should be made easy to attract house builders.

In the next phase of Modern Log City research program, mass customization will be studied as a strategic mechanism to develop design, participating and production processes of Finnish log house architecture. The aim is to find out what kind of elements of mass customization- user participation, standardization, prefabrication and supply chain management - prove useful in architectural and industrial context in Finland.

Developing aspects of mass customization could combine affordability with individuality and architectural quality and thus broaden the group of potential log home buyers.

References

Barlow, J., Childerhouse, P., Gann, D., Hong-minh, S., Naim, M. and Ozaki, R., 2003. Choice and delivery in housebuilding: Lessons from Japan for UK housebuilders. *Building Research and Information*, 31(2), pp. 134-145.

Barlow, J., 1998. From craft production to mass customisation? Customer focused approaches to house building, *Proceedings of IGLC 6th Annual Conference, Sao Paulo, Brazil, available at <http://cic.vtt.fi/lean/conferences.htm>* 1998.

Barlow, J. and Ozaki, R., 2001. Are you being served. *Japanese Lessons on Customer-focused Housebuilding. Report on a Department of Trade and Industry Expert Mission, SPRU, University of Sussex, Falmer, .*

Benros, D. and Duarte, J.P., 2009. An integrated system for providing mass customized housing. *Automation in Construction*, 18(3), pp. 310-320.

Bin Mohd Noor, M Z, 2017. *FlexZhouse: New business model for affordable housing in Malaysia*. TU Delft.

Cuperus, Y., 2003. Mass customization in housing an open building/lean construction study, *Proceedings of Dense Living Urban Structures International Conference on Open Building, Hong Kong, China 2003*, pp. 113.

Duarte, J.P., 2005a. A discursive grammar for customizing mass housing: The case of Siza's houses at Malagueira. *Automation in Construction*, 14(2 SPEC. ISS.), pp. 265-275.

Duarte, J.P., 2005b. Towards the mass customization of housing: The grammar Siza's houses at Malagueira. *Environment and Planning B: Planning and Design*, 32(3), pp. 347-380.

Geraedts, R.P., Cuperus, Y.J. and Shing, K., 2011. Timeless flexible building: Matching demand and supply in flexible housing, *Proceedings of the joint conference of CIB W104 and W110, Boston, USA, 15-17 November 2011* 2011, Ball State University, College of Architecture and Planning.

Hofman, E., Halman, J.I.M. and Ion, R.A., 2006. Variation in housing design: Identifying customer preferences. *Housing Studies*, 21(6), pp. 929-943.

Kwiecinski, K. and Slyk, J., 2015. Interactive design system for provisioning of customized houses, *eWork and eBusiness in Architecture, Engineering and Construction - Proceedings of the 10th European Conference on Product and Process Modelling, ECPPM 2014* 2015, CRC Press/Balkema, pp. 649-655.

Noguchi, M., 2005a. Japanese manufacturers' 'cost-performance' marketing strategy for the delivery of solar photovoltaic homes, *Proceedings of the Solar World Congress 2005: Bringing Water to the World, Including Proceedings of*

34th ASES Annual Conference and Proceedings of 30th National Passive Solar Conference 2005a, pp. 2341-2348.

Noguchi, M., 2003. The effect of the quality-oriented production approach on the delivery of prefabricated homes in Japan. *Journal of Housing and the Built Environment*, 18(4), pp. 353-364.

Noguchi, M., 2005b. Japanese prefabricator's means to commercialize mass custom homes equipped with photovoltaic solar electric systems, *Proceedings of the ACSA 2005 International Conference 2005b*, pp. 25-29.

Noguchi, M., 2004. A proposed choice model for the delivery of mass custom homes, *International housing research conference, Toronto 2004*.

Salvador, F., De Holan, P.M. and Piller, F.T., 2009. Cracking the code of mass customization. *MIT Sloan management review*, 50(3), pp. 71.

Viik, K., 2017. Oulun kaupungin omakotitonttikysyntä: Omakotitonttien kysyntäennuste 2017–2021.

Wang, Y. and Duarte, J.P., 2001. Automatic generation and fabrication of designs. *Automation in Construction*, 11(3), pp. 291-302.

Womack, J.P., Jones, D.T. and Roos, D., 1990. *Machine that changed the world*. Simon and Schuster.

Zipkin, P., 2001. The limits of mass customization. *MIT Sloan management review*, 42(3), pp. 81.