OPPORTUNITIES AND CHALLENGES TO MASS CUSTOMIZE LOW-INCOME HOUSING IN BRAZIL

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Abstract
Mass Customization (MC) stands for the ability to develop high value-added products within short time frames and at relatively low costs. Although this strategy has been successfully applied in several industries, in construction it has been mostly limited to a few companies that produce factory-built and manufactured homes. In Brazil, where traditional construction techniques are majorly adopted in low-income housing programs, there have been many critics regarding the excessive standardization and thus, non-consideration of the increasing diversity of households and their specific needs. Such standardization is mainly due to the use of mass production core ideas as a way to achieve low costs. The aim of this paper was then to explore the possibilities of adopting mass customization in this context. Two existing low-income housing programs in Brazil were investigated. The discussion on the opportunities and challenges to introduce mass customization ideas in these programs are based on the analysis of the product development process, as well as an analysis of household profiles and needs. The results indicated that the household profile is very diverse in low-income housing. Thus, demand for customization is high, as well as attributed to different products' characteristics. However, the product development process in this context was found to be very different from a process of mass customized products. Despite the need to modify such process, it was identified that mass customization can be achieved in a variety of ways, and does not necessarily imply on the modernization of construction techniques. However, a major challenge for achieving higher customization in this context seems to be related to the programs' rules and how it restraints innovation and diversity.

***Keywords**: product development process, low-income housing, mass customization, value management*

Introduction
In manufacturing, the need for more flexible products has been addressed through the delivery of mass customized products. In fact, mass customization has been pointed out as an effective way to achieve high-value added products within short time frames and at relatively low costs (Davis, 1987; Pine II, 1994). Davis (1987) was one of the pioneers in defining such term, referring to the strategy of reaching a large number of customers, as in mass production, while providing the individual treatment of craft production. Nowadays, such strategy may be viewed as a natural follow up for processes that have become increasingly flexible and optimized regarding quality and costs (Silveira *et al*., 2001).

Although mass customization has been widely used for competitive advantage in several industries, evidence of successful examples in the construction sector is restricted to markets of factory-built homes (e.g. Barlow *et al*., 2002; Barlow and Ozaki, 2003; Noguchi, 2005). Those authors pointed out that homebuilders rely partly on

modularization, pre-fabrication, and on site assembly to achieve mass customization. However, in Brazil, house building is still heavily based on traditional construction techniques. Moreover, a study identified that Brazilian companies using such techniques have difficulties to deal with the diversity of customers' needs and efficiently provide flexible homes (Brandão, 1997). According to that author, problems are not only related to the use of traditional techniques, but also to a poor management of customers' requirements throughout the construction process.

In Brazilian low-income housing programs, difficulties for considering customers` needs are far beyond technical issues, as a wide range of stakeholders are involved in the provision process. Since 1988 there has been major changes in governmental policies concerning housing. Nowadays, there is a range of housing programs, each focused on different social segments. Main rules and decisions are still taken by the government, but such programs are now constituted by a complex multi-stakeholder environment, brought together to develop, produce, deliver and sometimes even manage the use of low-income housing schemes. Therefore, to consider and manage costumers' requirements in such complex environment is very challenging (Leite, *et al*., 2011), mainly due to conflicting interests among stakeholders.

The importance of considering social and cultural diversity in low-income housing provision has been brought since 1992 as a major challenge for supporting sustainable development through public policies (Agenda 21). However, a study on a major existing housing program in Brazil has identified that project flexibility tends to be very limited due to the adoption of mass production core ideas in their conception as a way of reducing costs (Leite *et al*., 2011).

Therefore, the aim of this research was to identify opportunities and challenges for the adoption of mass customization in low-income housing in Brazil. Firstly, a conceptual framework regarding the operational issues that are necessary for implementing mass customization is proposed. Then, empirical data from two case studies are discussed. The studies were carried out in existing low-income housing programs, and comprehended two main phases: understanding the product development process (PDP) and mapping customization requirements.

Mass Customization

Mass customization is an approach that involves the entire value chain, from sourcing to final distribution (Piller, 2003; Duray *et al.*, 2002). According to Pine II (1994), companies moving towards mass customization usually begin by implementing one approach, or a combination of approaches that requires less modification on their existing processes. Also, the selection of the approach will depend on how the value chain is configured and when the customization process will take place (Pine, 1994; Duray *et al.,* 2000). Thus, the moment when costumers are involved in the process may determine the degree of customization and the most appropriate practical approach (Duray *et al.,* 2000). However, Pine II (1999) argues that some approaches may allow costumers to adapt the product by themselves, during the use phase, not needing to be involved in the product development process. Figure 1 presents four main approaches to achieve mass customization.

In this spectrum, practical approaches to mass customization are displayed according to the moment that customers are involved in the process, and how the value chain is organized to provide the customized product. In *Custom-tailored products*, costumers are involved in early phases of product development. The product may follow a modular architecture, but the costumer can interfere in the design phase (Duray *et al.,*

2000). Achieving customization through a *Combination of standard components* implies that design decisions have already been made and cannot be modified. This combination may involve standard designs or standard components that have already been produced (Pine II, 1999; Duray *et al.*, 2000). Product customization can also be postponed to the sales point, and realized through *Additional work* (Pine II, 1999). Finally, customization can be achieved by *Enabling customization during use* (Pine II, 1999; Duray *et al.*, 2000) or customized services can be delivered with standard products (Pine II, 1999).

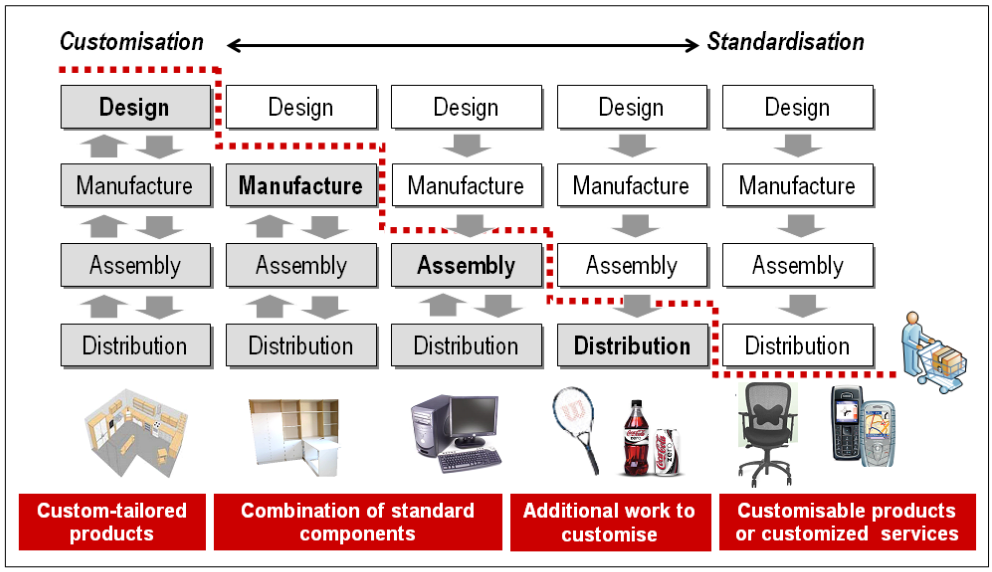

Figure 1: Practical approaches for mass customization in manufacturing

Depending on the practical approach for mass customization, different issues regarding the product development process need to be considered, regarding product's design, the production system and the supply chain design. Most approaches require a product with modular architecture, allowing the combination of components in different ways to generate a variety of solutions (Collina, 2004). Thus, economy of scale can be achieved through the production of standard elements, while variety is provided by combining those elements in different ways (Pine II, 1999).

Regarding the management of production systems, Pine II (1999) argues that the development of just-in-time production, lean manufacturing, time-based competition and other advantages that come along with the lean production philosophy, were the main enablers of increased product variety at relatively low costs. Flexible production systems allow companies to explore what has been named as economy of scope. This means that the same system is able to produce a wide variety of products, in a production line that is easy to be reconfigured while still exploring the economy of scale (Szwarcfiter and Dalcol, 1997).

Mass customization in the construction industry

In the construction sector, mass customization has been adopted mostly for industrialized housing production. Factory built homes can be delivered within short time frames and at relatively low costs, while maintaining product's quality (Noguchi, 2005). In that context, the customization process happens in three stages (Noguchi, 2005). Firstly, the company offers a catalogue with different types of house design for their clients. Options vary from different styles, technology and constructive elements. Such elements can be structural, defining the housing spatial characteristics, external,

defining the housing appearance and internal, defining functionality and interior appearance. In addition to that, it is also offered air conditioning, security systems and other accessories. Clients can combine those components in different ways, and a virtual image shows the final result with an estimated price.

According to Barlow *et al.* (2002), Japanese companies adopt different practical approaches for mass customization, which depends on how the supply chain is organized. Some companies customize through *Additional work* through simple and complementary production process close to the delivery point. Others involve their costumers in the assembly process, customizing through the *Combination of standard components*, while there are still some that have a *Custom-tailored* approach, involving costumers in the design phase and letting them request changes on modules. Thus, the Japanese industry can efficiently deliver mass customized homes by pulling production, using standard and pre-fabricated components and managing the supply chain.

However, in places where traditional construction techniques are widely used, it is more difficult to achieve such efficiency (Barlow and Ozaki, 2003). Hence, these authors suggest a transformation from a predominantly sequential, manual and fragmented process into the use of modular design, pre-fabrication and assembly of components, as well as an integrated process of design and production supported by efficient communication and coordination. In addition to the difficulties related to technical issues, Barlow *et al.* (2002) highlights the limitations imposed by urban policies; the long development cycles, which makes it more difficult to introduce customization; the constructors conservative attitudes towards innovative projects; as well as the attitude to consider only construction related activities, not considering the quality of supporting services to customers.

Research method

Case study was the research strategy used in this investigation. Two case studies were carried out in existing low-income housing programs in Brazil: the Associative Credit Program (CCA) and the Residential Leasing Program (PAR). In both cases, houses are acquired through low-interest loans from the government. The former aims at low-income families earning up to 10 minimum wage salaries, while the later is focused on families earning up to 6 minimum wage salaries. Those programs were chosen for being representative on the government efforts for delivering low-income housing. Moreover, in the CCA program, companies were aiming at a more costumer-centric approach, offering some flexibility in their products, this was seen as an opportunity to test the real possibilities of adopting mass customization on a real life context. Regarding the PAR program, previous researchers have done a considerable effort to understand the PDP and to map clients' needs, which was an opportunity to carry on a comparative analysis. The case studies were conducted in two phases: (a) analysis of the product development process, and mapping customization requirements

In phase 1, data for the CCA was collected through a set of interviews with the company's teams responsible for the product development process, and with the production manager, foreman and an intern at the construction site. Other sources of evidence were also important, such as the analysis of legal documents concerning the rules that have to be followed to develop a product for this type of housing program; direct observation at the construction site; participation on meetings between the company and the costumers; and the analysis of architectural drawings, users' manual, and other internal documents concerning the company's procedures. For the PAR program, secondary data was obtained from an existing database and research reports

that have been produced by UFRGS. Data from a previous investigation on the assessment of projects delivered by three small sized local companies (Leite 2005) was also analysed.

In phase 2, the main source of evidence was previously collected data of the CCA program (figure 2). The company had a close contact with clients throughout the PDP, which makes it possible to collect clients' profile, requests for change in the dwelling plan and post-occupancy evaluation. Data from three housing projects were analysed. All of them consist in low-rise buildings with a similar architectural typology but with different dwelling sizes (2 and 3 bedrooms). Other important source of evidence was a survey carried out in one of these housing schemes to evaluate adaptations in dwellings (sample size - 60%). During the application of the survey, data was also collected through direct observation and photos of the adaptations were taken under dwellers permit.

	Data available and sample size		
Housing Schemes	Clients' profile	Clients' requests for change in dwelling plan	Post occupancy evaluation
SL	63%	60%	45%
SC	75%	80%	61%
SJ	50%	93%	not available

Figure 2: Secondary data available in the company's database

Data analysed for the PAR case has being previously collected through a post occupancy evaluation carried out in a sample size of 20% (for each housing scheme). The questionnaire consisted of three main blocks: users profile, satisfaction and modifications in dwellings. Three different projects were analysed, all of them consisted of 2 bedroom dwellings, however they present different architectural typologies: in the first ones, dwellings are distributed in a four store building (schemes OR and RD); in the second one, dwellings are distributed in a five store building and delivered without finishing materials (scheme MR); and the third is a low rise housing project (scheme SR), similar to those analysed in the CCA case. In both cases, the scope of data analysis was levels of satisfaction and changes made on the dwelling interior spaces and the private open space (back yard and front entrance, when existing). Also, household profiles were analysed using a hierarchical cluster analysis technique.

CCA Program

In the CCA program, most activities are performed by a construction company, which is responsible for developing, building and delivering the housing schemes to final consumers, as well as monitoring the product's use after its occupancy. It is also the company's responsibility to gather potential costumers and develop a social work project to assist them on the legal issues regarding the acquisition and the definition of condominium rules. The city council and the financial institution have a secondary role on the process. The financial institution evaluates company's performance according to the program's rules, evaluates the product that is being developed, checking if it is in accordance with the city's urban legislation, as well as checks if prospective costumers have enough credit to obtain the loan.

Housing schemes developed by the company generally consist of a hundred of role dwellings. Usually, the highest possible occupancy ratio is considered, due to the high costs of land in Brazil. Although housing units were repetitive, the product design

cannot be characterized as modular. From the point of view of product architecture the project is considered to be integral, consisting of load-bearing block walls, with hydraulic and electrical systems close attached to it. After walls are built, they cannot be modified because of their load bearing properties. Therefore, changes in those systems must be planned well in advance, as extra features to allow flexibility in the block walls need to be pre-defined and then placed in the construction phase. Once the architecture and building services design have been finished, they have to be approved by the financial institution and the city council. The approved plan cannot be modified during the construction process, as there is another evaluation process before the product delivery, in which this issue is considered.

After receiving approval, the company can advertise and start building the housing scheme. Interested costumers are registered to apply for a loan contract with the financial institution. Since dwellings are commercialized at the beginning of the construction phase, costumers are allowed to request some changes to better suit their needs. The company offers a list of options that can be modified in the dwelling plan, giving a period of 30 days for costumers to request changes. The options are mainly some small changes on electrical and hydraulic systems, such as adding outlets and relocating the kitchen sink, or changes in finishing materials.

Flexibility is also limited due to legal restrictions. If costumers do not want the standard finishing materials in wet surfaces, they will receive them in boxes to exchange for another, as the company is not allowed to deliver the houses without such materials. Moreover, requests concerning spatial modifications are very difficult to be fulfilled since local authorities have previously approved that plan. Sometimes, the company receives requests for change after the 30 days period. In this case, there is a need to check in what stage is the construction, and if it is still possible to realize the request.

In the production stage each block of houses was built at a time. A block consists of two production batches of 3 to 5 units, and it takes around 4 months to build an entire block. After the completion of a batch of units and the necessary infrastructure, they are delivered to final costumers and the company starts to build the next batch. Building materials are normally bought for each block of houses, and the negotiation with suppliers start at the beginning of the production phase. The company has some steady local suppliers for most materials. Though, for ceramic tiles and bathroom accessories, the suppliers are located far away and they typically deliver standard materials in large batches, which enable the company to buy at a relatively low price.

Finally, dwellings are delivered in blocks and a monitoring phase starts. Besides maintenance services, the company also gets feedback from costumers in the point of delivery and with post-occupancy evaluation carried out at least after one year of product's use. Collected data is then analysed by the company's quality management staff, but it is not usually processed and analysed in time to feedback the next cycle of product development. Improvements are made based mainly on costumers' complaints and lessons learned through the direct contact with final users.

In the analysis of costumers' profile, the strongest variable distinguishing them was the income. Customers from housing schemes 1 and 2 have a similar income, while costumers from the third scheme have a higher income. Thus, five different household groups were identified (figure 3). In schemes 1 and 2 three main groups were: a large group of households with an average income, mostly young couples (43%), families with children (23%) and single parents (16%); households of mature couples with a higher income (8%); and young couples with lower income (9%). In scheme 3, three

groups were found: a large group of young couples and single parents with higher income (61%) and another group of young couples with an average income (39%).

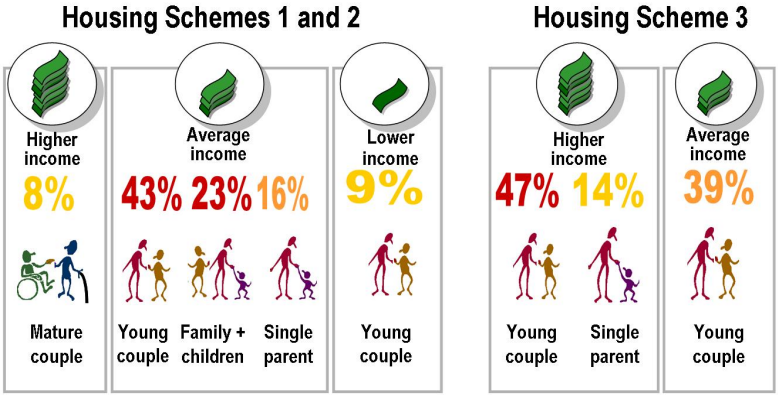

Figure 3: Cluster analysis of CCA households

Regarding requests for change, a high percentage of households opted to modify dwellings, besides the restricted flexibility offered (figure 4). The majority of changes are requested to change ceramic tiles. Also, changing the layout of electrical and plumbing systems is also quite requested, since it cannot be modified after it has been built. Some small modifications are also requested on brick walls, such as separating the kitchen space from the living room, and the least requested change is to modify direction of doors openings.

Regarding costumers' satisfaction, high levels of satisfaction were found. Issues that cause less satisfaction are the laundry room and kitchen space, as well as the quality of finishing materials (including the materials of doors and windows) (figure 5).

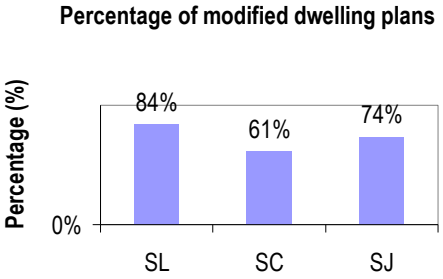

Figure 4: Modified dwelling plans on the CCA case

CCA Levels of Satisfacion	Dwelling interior spaces					Dwelling components			
	Living Room	Kitchen	Laundry room	Bedrooms	Bathroom	Doors and Windows	Eletrical System	Plumbing System	Finishing Materials
Very Satisfied	10%	6%	5%	11%	7%	3%	11%	2%	1%
Satisfied	64%	56%	49%	80%	66%	59%	67%	61%	49%
Neither Satisfied Nor Dissatisfied	16%	15%	14%	7%	12%	10%	8%	18%	13%
Dissatisfied	8%	20%	24%	2%	10%	16%	10%	14%	18%
Very Dissatisfied	3%	4%	8%	0%	5%	8%	4%	6%	8%

Figure 5: Levels of consumer satisfaction in the CCA program

Even though changes in plans are allowed, modifications after occupancy are common (figure 6). 96% of the interviewees have already added or is planning to add one more room in the back yard for leisure porpoise, with a barbecue place. Changing finishing materials, such as ceramic tiles, wall painting and bathroom metals; are the second

most frequent type of modification after occupancy. Other changes such as adding air conditioning and security elements, such as fences, were also observed.

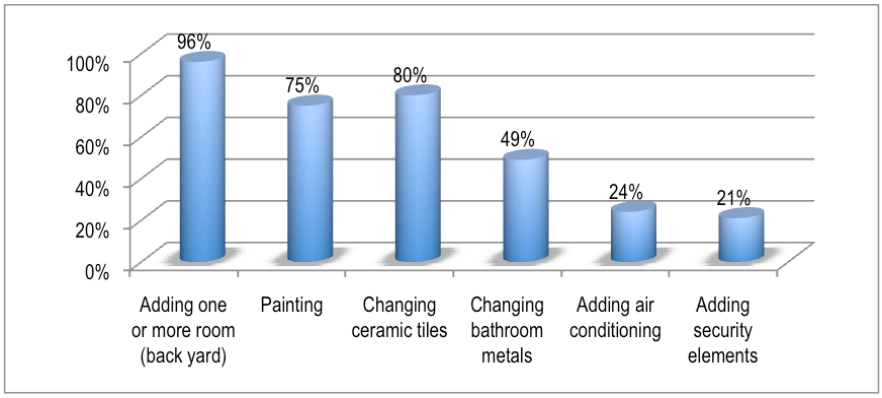

Figure 6: Most common modifications in dwellings after occupancy – CCA program

PAR program

In the PAR program, there were four main stakeholders participating on the provision process. In this case, the government has a greater influence on the configuration of final product, since it establishes some design restrictions to be followed by the construction companies (e.g. the price has to be the same for all dwellings, there are minimum areas to be followed). Different from the CCA program, in this context it is not the company that advertises the product and gathers potential costumers, instead, the government advertises the possibility to participate in this program in a given city, registering the interested families. Another peculiarity is that after dwellings are built the government is responsible for distributing dwellings to final users. The bank also has some other additional activities rather then just evaluate and approve the product. In this case it is the financial institution that develops the social work (rather than the construction company) with the families throughout the entire process, including post occupancy phase. This is also a leasing program, in which dwellings remain as government property for 15 years. Throughout this period, a facility management company is hired to supply administrative services such as collect users' complaints and assure monthly payment.

When the company starts developing the housing schemes the scope of the solution has already been narrowed by the some pre-established design specifications. There are three types of housing that can be built: new and simplified dwellings with no finishing materials for a lower price, new and complete dwellings, or dwellings in a refurbished building. For each category, dwelling units within the same scheme need to have the same price. The design of the housing is based on minimum requirements previous established by the government. Previous studies identified that companies use a concept of generic and specific product design (Leite *et al*., 2005).

The city government opens the period of application for interested families. A demand of 4 families for each unit is necessary for the housing scheme to start to be built. Credit conditions of these households are then analysed. Once the families are qualified, social workers contact them to collect information and provide some advice about the leasing process and on how to live in a condominium.

Housing construction is clearly mass production oriented. Repetitiveness is used to reduce overall costs of production, large batches of materials are bought and dwellings are produced sequentially. Although the houses are repetitive, the product design

cannot be characterized as modular. As in the CCA program, the product has an integral architecture, consisted of load-bearing block walls, with hydraulic and electrical systems closed attached to it.

The construction process has to follow a bar chart that is proposed by the company and approved by the financial institution. During the construction period the financial institution visits the construction site periodically to check if the chronogram is being followed. When construction is done, the construction company delivers it to the financial institution, which will distribute dwellings among selected families at random.

After dwellings are delivered, a facilities management company is hired to take care of managing the condominium, so that that the housing estate is properly managed. Units are not supposed to be modified during the leasing period. Only after 15 years, when leasers can become homeowners it is possible to realize changes on the dwelling space.

In the PAR case, three main groups were identified (figure 7). Since data about income were not available, it was used the variable level of education instead. In this case, the variable that most distinguished households was the level of education. Also, differently from the previous case, a larger amount of mature households were identified. Interestingly, lower levels of education were found among older households, while higher levels of education were found among the young ones. The largest cluster is formed by families with children and secondary education. There are also a group of households with higher education composed by single parents and young couples, and a group with primary education composed by mature couples and mature couples with children living at home.

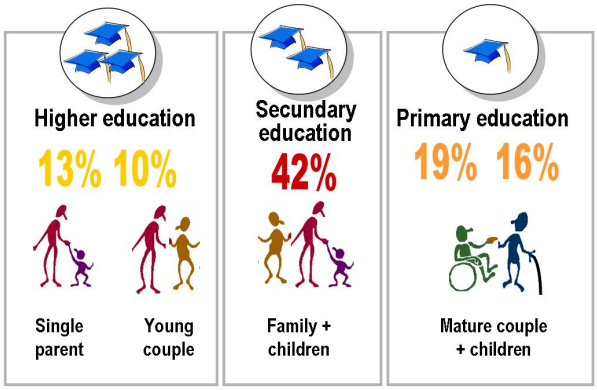

Figure 7: Cluster analysis of PAR households

Results regarding costumers' satisfaction were very similar from the CCA case. High levels of satisfaction were found, although the laundry room and kitchen space, as well as the quality of finishing materials were the main causes of dissatisfaction among interviewees (figure 8).

PAR Levels of Satisfacion	Dwelling interior spaces					Dwelling components				
	Living Room	Kitchen	Laundry room	Bedrooms	Bathroom	Doors	Windows	Eletrical System	Plumbing System	Finishing Materials
Very Satisfied	10%	7%	6%	9%	12%	4%	10%	11%	10%	4%
Satisfied	72%	63%	43%	76%	80%	59%	74%	70%	77%	54%
Neither Satisfied Nor Dissatisfied	6%	4%	8%	4%	1%	3%	3%	3%	3%	6%
Dissatisfied	11%	23%	33%	10%	7%	17%	12%	13%	13%	20%
Very Dissatisfied	1%	3%	14%	1%	0%	1%	0%	3%	3%	7%

Figure 8: Levels of consumer satisfaction in the PAR program

Not only satisfaction levels, but also post-occupancy modifications in the PAR program were very similar from the CCA case. Most common modification was the addition of a barbecue place or leisure space (figure 9). Changing the walls painting and finishing materials were also very common. It is worthwhile to mention that even though dwellers are not allowed to modify the building structure, it was identified the addition of air conditioning and modifications in the electrical system.

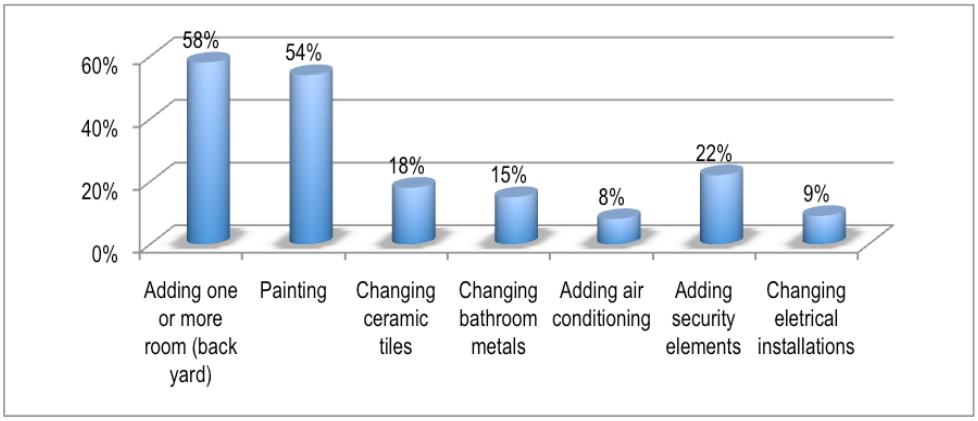

Figure 9: Most common modifications in dwellings after occupancy – PAR case

Discussion and conclusions

Despite of the fact that these housing schemes are designed for a standard household of a couple with children, a great diversity was found in household profile. Moreover, even though these housing programs are conceived to fulfil the needs of low-income families, usually treated as a homogeneous demand, variables representing income and level of education were found to be dramatically different among households in both programs. This may represent a diversity of life styles, which is not being considered. Hence, with such diversity, incremental costs to achieve differentiation may not imply in costumer dissatisfaction. The nature of customization requirements was found to be similar in both programs. Common modifications after occupancy are the extension of dwelling for a barbecue place or other leisure purposes, as well as the personalization of finishing materials.

Considering the findings on major customization requirements, as well as the different practical approaches found in the literature, it was found that mass customization could be adopted through three different approaches: (a) Custom tailor or combination of components to provide more adequate spaces for the diversity of life styles; (b) Customization through additional work, in which the companies could offer personalized finishing materials or the addition of complementary elements, such as barbecues of safety systems; (c) Enable customization during use by delivering houses without finishing materials and/or providing instructions to add or change elements in the future.

However, by analysing the programs' developing processes, it was observed that in spite of the opportunities to adopt mass customization in this context, there are many barriers to overcome. Regarding general aspects, it was observed that the CCA context provides better supporting elements: (a) most activities are performed by the construction company; (b) there is high competition among companies in this market

segment, thus high susceptibility to demand risks; (c) the company that develops the product has a close contact with costumers; (b) the company has a system for capturing costumers information to feedback the development process; (c) dwellings can be priced differently, according to size and number of bedrooms; (d) dwellings are produced in small batches and delivered to costumers; (e) there is a major concern to compete in the market and to develop attractive products.

Conversely, in the PAR program, the development process is highly fragmented and mainly driven by governmental rules. In this context, a larger number of stakeholders perform activities in a less integrated manner. For instance, the company that develops the product does not have any contact with final users. It is the city government and the financial institution that selects and gives support to households throughout the process.

Along with the fragmentation, the activities are also heavily based on rules. Thus, Companies that are developing the housing schemes tend to limit themselves on following those rules and aim at lower costs rather than focusing on costumers expectations. A major distinction between the two programs also contributes for this fact. Differently from the CCA case, companies in the PAR program are not as susceptible to demand variations, as such demand is previously analysed by the government, which takes the responsibility of it. Further findings regarding the opportunities and challenges are summarized in figure 10.

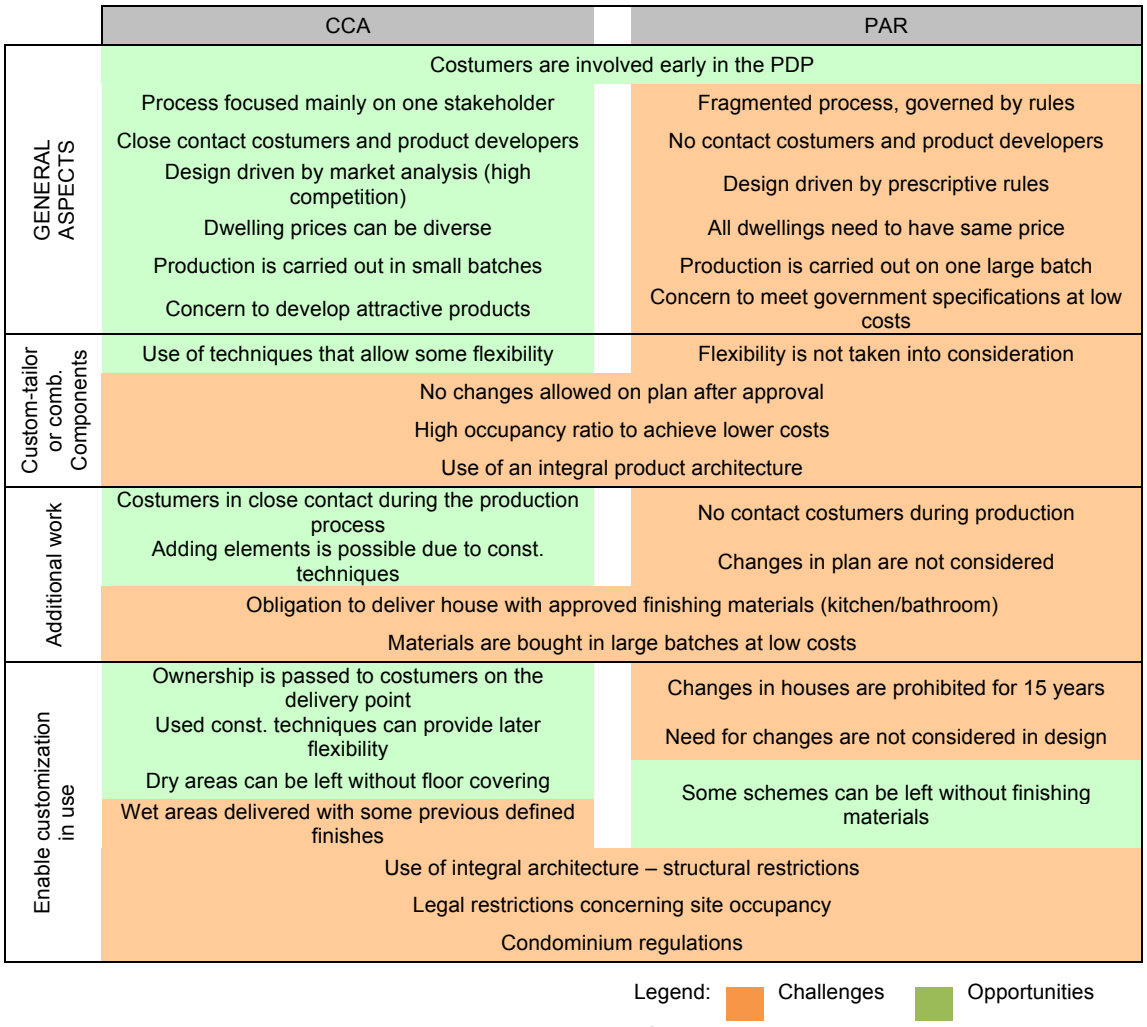

Figure 10: Main opportunities and challenges for introducing mass customization

Considering a *Custom-tailor* or a *Combination of components* approach, one of the major barriers is the high costs of land, which limits design to achieve a high occupancy ratio, thus inhibiting the development of different solutions. Moreover, the need for early approval of plans restricts further changes. As a consequence, an integral architecture has been adopted to reduce costs, providing very limited flexibility on systems in which changes are allowed.

Program rules should stimulate design variety, allowing dwellings with different prices and focusing the evaluation and approval of products platforms instead of crystallized solutions. In both programs the early involvement of costumers is an opportunity for product co-development. A product with a modular architecture would enable standardization, repetitiveness and economy of scale while also providing variety (Duray *et al.* 2000; Collina, 2004). Along with that, the production system has to be designed to support flexibility. In this sense, the CCA case provides a more supporting system as the production is carried on in small batches.

Barriers related to the programs regulations could partially restrain an *Additional work* approach, as well, as dwellings need to be built as planned and delivered with previously specified materials. However, in the CCA program, the close contact with

costumers during the production phase in addition to the use of techniques that allow some flexibility is an opportunity to adopt such approach. Having in mind the high demand for materials finishing customization, an alternative could be to build standard dwelling units and postpone the customization of finishing materials as suggested by Stalk and Hoult (1990) and Child *et al*. (1991). In this sense, a flexible and more integrated supply chain is desirable. Products should be co-developed with materials suppliers, which in fact, could work with more flexible lead times, prices and order sizes.

Also, regulations are the main hinder to adopt an *Enable customization in use* approach. During the product's use, consumers should be stimulated to modify the space according to their needs, and for that, guidance should be provided. Spatial requirements could also be anticipated in design stage and a plan for future expansion could be delivered to households along with dwelling units. In the PAR program, rules concerning the products use may be a hinder to customization, as costumers are not allowed to make any changes for a period of 15 years. Moreover, in both programs, urban legislation regarding site occupancy would also be a barrier, along with further condominium rules in the CCA case, through which rules for modifying dwellings should be agreed by all. Only by overcoming those regulations it would be possible to think about a modular design that could support further adaptations during use.

REFERENCES

BARLOW, J. et al., 2002, Choice and delivery in housebuilding: lessons from Japan for UK housebuilders. Building Research & Information, Londres, v. 31, n. 2, p. 134-145, jan. 2002.

BARLOW, J. and OZAKI, R., 2003, Achieving Customer Focus in Private Housebuilding: current practice and lessons from other industries. Housing Studies, Bristol, v. 18, n. 1, pp. 87–101, jan. 2003.

BRANDÃO, D. Q., 1997, "Flexibilidade, variabilidade e participação do cliente em projetos residenciais multifamiliares: conceitos e formas de aplicação em incorporações" Msc. Diss., Civil Engrg., Federal Univ. of Santa Catarina, Florianópolis, Brazil. 235 pp.

CHILD, P. *et al.* 1991, "The management of complexity." Sloan Management Review, Fall, pp. 73-80.

CHRISTOPHER, M., 2000. "The Agile Supply Chain: Competing in Volatile Markets." Industrial Marketing Management, 20, pp. 37-44.

COLLINA, L., 2004. "System Architecture". In: MANZINI, E., COLLINA, L. and EVANS, S. (eds.). Solution Oriented Partnership: how to design industrialized sustainable solutions. Cranfield University, Cranfield, 171 p.

DAVIS, S., 1987, Future Perfect. Addison-Wesley, Reading, 243 p.

DURAY, R. *et al.,* 2002, "Mass customization origins: mass or custom manufacturing?" International Journal of Operations and Production Management, Bradford 22, (3), 314-328.

DURAY, R. *et al.,* 2000, "Approaches to Mass Customization: Configurations and Empirical Validation." Journal of Operations Management, 18, (6), 605-625.

LEITE, F. L. *et al.*, 2011, “Client Requirements Management in Social Housing: A Case Study on the Residential Leasing Program in Brazil”. Journal of Construction in Developing Countries, v. 16, p. 47-67, 2011.

NOGUCHI, M., 2005, “Japanese Manufacturers’ ‘Cost-Performance’ Marketing Strategy for the Delivery of Solar Photovoltaic Homes”. Proceedings of Solar World Congress ISES 2005, Orlando, U.S., 6-12.

PILLER, F., 2003, “What is Mass Customization? A focused view on the term”. Mass Customization News (Newsletter), Munique, DE, 6, (1), 16 p.
PINE II, B. J., 1999, ”Mass Customization: The New Frontier in Business Competition”. Harvard Business School Press.

SILVEIRA, G., *et al.*, 2001. “Mass customization: Literature Review and Research Directions”. International Journal of Production Economics, 72, (1), 1-13.

STALK, G. and HOUT, T., 1990, “Competing Against Time: How Time-based Competition is Reshaping Global Markets”, Free Press.

SZWARCFITER C. and DALCOL, P. R. T., 1997. “Economias de Escala e de Escopo: Desmistificando alguns Aspectos da Transição”. Revista Produção, Belo Horizonte, 7, (2), 117-129.