Is Customization Fruitful in Industrialized Homebuilding Industry?

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Abstract: The level of customization currently being built by U.S. industrialized homebuilders, including modular and manufactured homes producers, is characterized and the impacts of customization on plant operational performance, and employee and customer satisfaction are examined. To assess the current state of the industry, including the level of customization offered and operational performance, a large-scale survey of industrialized housing producers was conducted. Results revealed that in general, the operational performance of the surveyed homebuilders deteriorates with an increase in home customization. Producers that offer more customization tend to be less efficient in their use of manufacturing space and less efficient with their labor. Results also show that a higher level of customization leads to higher employee satisfaction (lower labor turnover) and leads to lower customer satisfaction. However, those producers that had active quality programs (e.g., continuous improvement) had higher customer satisfaction ratings. Therefore, industrialized housing manufacturers have not reached the ideal of mass customization (i.e., effectively managing the production complexities of customization) and are paying a price for offering more choices to their customers. Lessons learned from this study and mass customization enabling factors are discussed. DOI: 10.1061/(ASCE)CO.1943-7862.0000396. © 2011 American Society of Civil Engineers.

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Introduction

The housing industry is faced with homebuyers demanding houses that reflect their personal and unique style and homes that are individually configured according to their needs. Thus, there is an increasing customer demand for variety (Hofman et al. 2006). However, builders do not want to sacrifice production efficiency by deviating from their standard models (NAHB 2004). Changes can disrupt the entire estimating, production, delivery, and management process; making it even more difficult to manage homebuilding effectively. As a result, homebuyers are forced to choose from a limited number of standard products offered by large production builders or pay a substantial premium for a custom home built by a smaller custom builder. On the other hand, builders do want to obtain high consumer satisfaction ratings for their industrialized homes. This results in a dilemma for builders who must decide between high production efficiency or great customer ratings. If builders comply with homebuyers customization requests, how is their productivity affected? This research aims at addressing this challenge by investigating the levels of customization and efficiencies of industrialized homebuilding.

U.S. Industrialized Homebuilding Industry

Industrialized homebuilding is an innovative approach to homebuilding, which relocates many field operations to a more controlled factory environment. In the United States, the industrialized homebuilding industry includes the following: (1) manufactured homes, which are built to the Federal Manufactured Home Construction and Safety Standards promulgated by the U.S. Department of Housing and Urban Development (HUD) (U.S. Department of HUD 2006) and (2) modular homes, which are built to local building codes similar to site built homes. Even though manufactured homes follow more stringent building codes (e.g., additional bracing), both types of industrialized homes share similar construction methods. Thus, from a process perspective, both types of industrialized homes are considered equal and referred to herein as industrialized homes. From a product perspective, both types of industrialized homes are built from a few common core building elements (i.e., floors, walls, and roofs). Typically, industrialized builders offer their customers a number of standard models and allow different levels of customization that range from a predetermined set of options (mostly raw material or component substitution) to unique home designs. Industrialized homes are produced as “ready-to-live” volumes or 3D modules (with integrated finishing, cabinets, electrical installations, and so on) that are transported to the construction site and assembled there into a completed house (Höök and Stehn 2008). A typical production line is set up either in a sidesaddle configuration (widthwise section movement) or in a linear configuration (lengthwise section movement) with floors, ceilings, walls, and other components being fed to the main line from offline subassembly stations and in a just-in-time sequential manner. Upon completion in the factory, these 3D modules are transported to the construction site, then lifted by crane or rolled onto a foundation. While the house is being built at the plant, workers do the needed site work and prepare a foundation.
if required. The resulting home is often indistinguishable from nearby conventional site-built housing (Mullens 2004).

In 2007, approximately 11% of all newly-built single-family homes in the United States were industrialized (U.S. Census Bureau 2007). Historically, industrialized housing sales have lagged site-build housing. Contributing factors include consumer’s perception of factory-built homes, pricing relative to site-built, and lack of customization (Mullens et al. 2004).

Current Trends in Customization and Homebuilding

From a customer’s perspective, customization provides superior customer value by producing goods and delivering services that meet individual customer needs (Tseng and Jiao 2001). From a product design perspective, having all possible variations of a product might be feasible. However, from a production and logistical point of view, design choices should be restricted to as few as possible to achieve cost efficiencies (Blecker et al. 2005). This situation is true in the housing sector, where builders try to limit the level of choice to achieve economies of scale in the construction process (Barlow et al. 2003). From a manufacturer’s perspective, customization is viewed as another customer demand that challenges their capability to maintain the cost, quality, and speed of operations. Changes owing to product customization can disrupt the entire estimating, production, delivery, and management process, making it even more difficult to manage operations effectively. Typically, product standardization is associated with efficiency and customization is associated with inefficiency and high costs. However, customization practice shows that consumers are frequently willing to pay a price premium for customization to reflect the added value perceived by the individualized solutions (Tseng and Piller 2003). The added value causes an increment of utility that customers gain from a product that better fits their needs when compared to the standard offerings available. The literature reflects this dichotomy, often distinguishing between creativity and efficiency (e.g., Benner and Tushman 2002). Certainly, the tradeoff between customer choice and productivity (between creativity and efficiency) will be a critical element of business strategy for the 21st century home manufacturers.

Pine and Gilmore (1999) introduced a taxonomy model to classify firms that pursue a customization strategy based on customer needs and classify customization on the basis of the capability of avoiding a specific customer sacrifice. The authors define customer sacrifice as “the difference between what a customer accepts and what he/she really needs, even if the customer doesn’t know what that is or can’t articulate it” (Pine and Gilmore 1999). In this context, they identified four distinct approaches to customization, which include the following: collaborative, adaptive, cosmetic, and transparent. In collaborative customization, customers select from predetermined components, and then the product is custom made. In adaptive customization, only one customizable product is offered, and the product is designed so that users can alter it on their own. Cosmetic customization presents a standard product differently to various customers. Transparent customization provides individual customers with unique goods or services without letting them know explicitly that those products and services have been customized for them. Typically, this type of approach requires long-term relationships between the manufacturer and customers. Pursuing any of the customization strategies presented by Pine and Gilmore (1999) will have an impact on product design and operational performance.

Pine and Gilmore’s (1999) conceptualization of customization strategies focuses on the customer and their sacrifice. An alternative perspective is that of Duray et al. (2000) who focus on an operation perspective to product customization. They present a customization classification on the basis of two dimensions, which include the following: the point of customer involvement and the type of modularity. These dimensions are evaluated in relation to the production cycle consisting of the design, fabrication, assembly, and use phases. Duray (2002) concurs that the point of customer involvement in the production cycle is a key indicator of the degree or type of customization provided. If customers are involved in the early design stages of the production cycle, a product could be highly customized. If customer preferences are included only at the final assembly stages, the degree of customization will be less. In this manner, the point of customer involvement provides a practical indicator of the relative degree of product customization. Duray et al. (2000) juxtaposed both dimensions of customer involvement and modularity, resulting in four different archetypes, which include the following: fabricators, involvers, modularizers, and assemblers. Fabricators are willing to use common components, but they may also tailor or design new components to meet customer requirements. Involvers allow customers to take part in the design and fabrication process, and the customization is done during the assembly phase by combining standard components. Modularizers use common components in many product lines, and customization is done in the assembly or use phase. Assemblers use standard components and allow customers to take part in the late stages of the production cycle.

Mass customization is an approach to address the tradeoff between customization and industrialization. The term “mass customization” was coined by Davis in his seminal book, Future Perfect (Davis 1987). The concept of mass customization as a manufacturing strategy was popularized by Pine (1993). Mass customization is an emerging production paradigm that seeks to design and manufacture customized products at mass-production efficiency and speed (Pine 1993). The concept has been proposed as a potential strategy for competitive advantage; however, company-wide implementation of mass customization is hindered by the lack of validated operational strategies to customize on a mass scale (Tseng and Piller 2003). Mass customization in the housing industry context refers to the ability to design and manufacture customized houses at mass production efficiency and speed. However, with all the technological advances and innovative home-building technologies available today, builders still face several challenges while trying to achieve mass customization. One of the most critical challenges is the operational challenge of how to provide customization without affecting the basic efficiency of the production process.

Mass customization strategies have been primarily categorized by the point of initial customer involvement. Lampel and Mintzberg (1996) define a continuum of five strategies that extend from no involvement (pure standardization) to involvement starting in design (pure customization). The five customizing strategies include the following: pure standardization, segmented standardization, customized standardization, tailored customization, and pure customization. Pure standardization refers to the case in which the end product is the same and where the customer does not get involved before taking possession of the product. In segmented standardization, firms respond to the needs of different clusters of buyers, but each cluster remains aggregated and the product produced for the cluster is the same. In customized standardization, products are made to order from standardized components. Tailored customization requires a basic product that can be customized in the fabrication stage. In pure customization, the product is customized from scratch. However, there has to be some initial standard
configuration, otherwise this strategy corresponds to prototyping rather than customizing.

Among the many mass customization enabling factors identified in the literature, lean production represents a particularly interesting topic for research because of its application challenges in a mass-customization environment. The literature identifies continuous improvement as a shared principle in both lean and mass-customization concepts. Thus, lean production could be an instrument for homebuilders to achieve and maintain continuous improvement at the operational and enterprise level. Tu et al. (2001) and Da Silveira et al. (2001) argue that lean production is an important factor that supports mass customization. Conversely, Qiao et al. (2004) argue that the efficiency of lean production is diminished in an environment where the product mix changes irregularly and drastically, and where downstream processes require randomly customized parts on flexible schedules to be supplied from their predecessor processes on short notice. Under these conditions, Qiao et al. (2004) argue that extra inventory, equipment, and labor are needed to compensate for product and order variations. Chandra and Grabis (2004), however, argue that lean production can be an effective strategy for customized products with stable demand. For example, cellular manufacturing (Bedworth et al. 1991), a lean production technique, uses a flexible workplace and flexible workforce to enable the efficient production of a family of products on the same line. Thus, there are some benefits to be realized from the use of some lean principles in a mass-customization environment. Although the goal of both mass customization and lean production is to reach production efficiencies, lean principles are not necessarily concerned with increasing product variety.

In construction, the application of the lean production model stems from a discussion of Koskela’s work (1993), which emphasized the importance of the production process flow and aspects related to converting inputs into finished products as an important element to the creation of value over the life of the project. In the industrialized homebuilding context, factory configuration plays an important role in production flow, particularly when there is considerable product variation. Queuing availability and the flexibility for work to migrate upstream/downstream from the main production line can mitigate some of the inefficiencies resulting from high product variation (Mullens 2004). Information technology can enable better planning and management under conditions of high product variation.

Customization in the housing industry context refers to houses that have been individually configured according to customer specifications before construction commences. Customized houses might imply changes of varying difficulty, ranging from changes in the core concept, dimensional changes (e.g., floor plan), or change in features and/or finishes. The survey used to assess the level of customization currently being offered by U.S. industrialized homebuilders identified only four levels, which include the following: no customization (no departure from base model shown in marketing literature), minor floor plan change (e.g., stretches or flips of the base model floor plan), extensive floor plan changes (e.g., new kitchens or completely new floor plans) and total customization (i.e., a new sheet of paper). As the intention of the survey was to capture production efficiencies, all levels of choice, except the simplest of substitutions (e.g., change in finishes), were considered in the survey analysis because these substitutions are not likely to cause variation on work content and labor hours.

Typically, builders allow homebuyers to customize their house’s floor plan by adding custom features, components, and finishes, for example, for a price premium. However, there are restrictions on the choices offered to homebuyers. Apart from the constraints imposed by the size and shape of the plot and building and planning regulation, builders try to limit the level of choice in order to achieve efficiencies in the construction process (Barlow et al. 2003). Furthermore, the type of building system used affects the ability to offer choice (e.g., industrialized housing versus stick build). Recent research about construction firms in countries such as Japan (Barlow et al. 2003; Gann 1996; Noguchi 2003; Naim and Barlow 2003), the United States (Kendall and Teicher 2000), Great Britain (Ball 1999; Ozaki 2003), and the Netherlands (Van den Thillart 2004) shows that several firms are exploring ways of delivering higher levels of customization in housing design (Hofman et al. 2006). Investigating Japan’s industrialized housing industry, Barlow et al. (2003) identified examples of Lampel and Mintzberg’s five customizing strategies including pure standardization (standardized product and customer does not get involved before taking possession of the product or no customization), segmented standardization (standardized product based on clusters of buyers), customized standardization (products are made to order from standardized components), tailored customization (a basic product that is customized in the fabrication stage or minor/extensive floor plan changes), and pure customization (product is customized from scratch or totally custom). For example, Sekisui House manufactures standardized components and subassemblies that are shipped to the construction site where they are configured and assembled on the basis of the customer’s requirements. This strategy was categorized as tailored customization because homebuyer involvement started at the fabrication stage, before the modules were assembled in the factory. This strategy also allows for more design and specification choices to be offered.

**Customization and Employee Satisfaction**

Employees are a critical resource for industrialized home manufacturers. They certainly have first-hand knowledge of the production processes and an understanding of how they can be improved to accommodate product variety. However, the industrialized homebuilding industry is characterized by a high annual employee turnover (approximately 61%) (MHRA 2005), which could jeopardize the home quality through increased learning curves with newer employees. Thus, employee satisfaction is a key factor that needs to be taken in consideration in a high product customization environment.

 Builders can reduce employee turnover by taking steps toward improving employee job satisfaction. Udechukwu (2007) found that job satisfaction has an important effect on employee turnover. Job satisfaction has been an important research topic in organizational behavioral literature (Ghazzawi 2008). According to Herzberg et al. (1959), job satisfaction can be attributed to personal growth, achievements, responsibilities, and recognition. One of the most important factors affecting job satisfaction is an employee’s work situation (George and Jones 2008). An employee’s work situation incorporates the levels of challenges and diverse and interesting tasks performed by the employee in day-to-day activities. The firm with the higher rate of customization will require its employees to perform more diverse and challenging tasks in comparison with employees of firms, which provide low or no customization. Literature shows that diverse and more challenging jobs positively affect job satisfaction (George and Jones 2008), resulting in higher job satisfaction for employees of firms with higher customization.
Customization and Customer Satisfaction

Improving customer satisfaction has been identified as one of the most important challenges facing businesses, and keeping homebuyers satisfied is rapidly becoming the way many companies differentiate themselves from their competitors (Torbica and Stroh 2001). Customer satisfaction can be characterized as “post purchase evaluations of product quality given repurchase expectations” (Anderson and Sullivan 1993). Satisfied customers are valuable to firms as they are more likely to pay higher prices and generate positive word of mouth (e.g., Homburg et al. 2006). Whether buying commodity products or customized products, customers still demand high quality. The task of maintaining high quality over time becomes more difficult as managers try to balance expanding revenues through quality improvements and obtaining efficiency through cost reductions (Mittal et al. 2005).

In the case of the industrialized homebuilding industry, managers can reduce costs by providing a lower level of customized houses to consumers.

Tu et al. (2001) found a positive impact of product customization on value to customers—an external measure of the customer’s degree of satisfaction with a product. Therefore, customers want products that meet their needs, and if the company has customization capabilities then it should be able to effectively and profitably respond to its customer demands. One key to achieving customer satisfaction through customization is on the basis of a company’s strategy for helping customers make purchase decisions (Abu-Shalback 2004). There is evidence in the literature that there is a wide array of industries using different types of customization strategies with good business results. This implies that there is not one single strategy to customization. Kahn (1998) argues that a successful strategy resides in a company’s ability to make their product-process choice strategy work, stating “each customer finds exactly the option he or she desires” (Kahn 1998). Thus, it can be safely concluded, irrespective of the type of customization strategy employed by the company, that one should be able to achieve a positive impact on customer satisfaction through customization.

Method

Sample and Data Collection

The target population for the survey was a set of 150 industrialized home producers across the United States; together, they operate 275 plants. Surveys were distributed to a key decision-maker at each company, usually the president or CEO, to coordinate the data collection at their plants. Surveys were distributed via E-mail and the results were gathered during a 4-month period. In total, 141 plants completed the survey, representing 51% of the 275 operating plants initially contacted. The survey, developed by the Manufactured Housing Research Alliance (MHRA) in collaboration with the writers, includes various measures of the level of choice offered and plant performance. The data was collected by the MHRA, which was a great advantage as far as a broader outreach and response rate of the industry.

Participating plants recorded their answers for each survey question in a spreadsheet. If a plant left any question unanswered, this plant was not included in the analysis pertaining to the unanswered section of the survey. The survey, developed by MHRA in collaboration with researchers from the University of Central Florida, included various measures of the level of choice offered and plant performance (MHRA 2007). This represents a limitation of the type of data collected because it was primarily intended to establish benchmarks and new performance targets for the industrialized home producers. Suggestions on additional factors, on the basis of the literature, are presented subsequently in the future research section.

The level of product customization offered was documented in this study by using the following question:

- Q1: What level of customization have you provided on these models (e.g., models produced in the past year)? Please indicate the percentage of homes produced last year in the following categories: no customization (no departure from base model shown in marketing literature), minor floor plan change (e.g., stretches or flips of the base model floor plan), extensive floor plan changes (e.g., new kitchens or completely new floor plans), and totally custom (e.g., new sheet of paper).

A broad range of plant characteristics and operational performance indicators were also documented for each participating plant. These included annual sales, number of orders in the backlog, plant configuration (e.g., number of stations and plant size), quality, customer satisfaction, employee satisfaction, safety, and labor productivity.

Hypotheses

The overriding goal was to characterize how much customization is currently being offered by U.S. industrialized homebuilders and examine the impacts of customization on plant operational performance. The following hypotheses were examined:

- H1: Production efficiency declines with increasing customization.
- H2: Employee satisfaction differs with the level of customization offered, high customization should lead to higher employee satisfaction.
- H3: Customer satisfaction differs with the level of customization offered, high customization should lead to higher customer satisfaction.

To investigate these hypotheses, a set of statistical analyses was performed. First, a Pearson correlation and descriptions of all the variables of interest were conducted. Then, analyses of different models of multiple regression were conducted.

Measures

To conduct the data analysis, the survey data were processed and the following variables were documented and/or calculated for each category: product customization (independent variable) and operational performance metrics (dependent variables).

Customization. Participants were asked to provide the percentage of customization level based on the following four categories: no customization, minor floor plan changes, extensive floor plan changes, and totally custom. Then, the degree of customization measure was calculated by using the following formula:

degree of customization = [(0 × customization) + (0.333 × minor floor plan changes) + (0.667 × extensive floor plan changes) + (1 × totally custom)]

Operational performance. Data from the survey were processed and the following measures were documented and/or calculated to reflect operational performance of each plant:

1. Labor cost (direct) per sale. The participants were asked their annual direct labor cost and sales. Direct labor costs were measured using the single question, “What is the plant’s annual direct production labor cost (total wages including bonuses without fringe/benefits) and the number of employees in each category?” Similarly, sales were measured using the single
question, “What are the annual sales of this plant?” This measure, which expresses hands-on labor consumed per sale, is a key measure of labor resource productivity.

2. Employee satisfaction. The participants were asked to mention their average percentage of production labor turnover. This metric was used as the proxy for measuring employee satisfaction. This measure describes the stability of the workforce and is an important measure of employee satisfaction. The lower the labor turnover is, the higher the employee satisfaction will be.

3. Quality improvement programs. The participants were asked to mention the number of different continuous improvement programs conducted in the previous year. Quality improvement programs require employee involvement and result in empowered employees and an improved product and processes (Evans and Lindsay 2008). Hence, because of the improved product, it is expected that there will be a significant impact on customer satisfaction.

4. Incentive pay program. Participants were asked to mention the number of incentive pay programs provided for employees in the previous year. This measure is important because when companies ask employees to assume new challenges and responsibilities, owing to increase product customization, incentives are the key to sustained individual efforts (Evans and Lindsay 2008).

5. Customer satisfaction. The participants were asked to mention the percentage of customers who were satisfied with their home purchase. The customer satisfaction percentage was obtained from the data collected by builders via their internal customer satisfaction survey procedures, e.g., the customers complete a survey. This measure summarizes the value that the plant provides to the customer, both in terms of product and service. Plants on the lower end of the scale should identify root causes of customer dissatisfaction in all aspects of the business and concentrate on developing and implementing solutions.

6. Manufacturing space efficiency. The participants were asked to mention their current production level (modules per week) and plant size. Current production level was measured using the single question, “What is the current production level—modules per week?” Similarly, plant size was also measured using the single question, “What is the current size (square feet) under the roof of the production facility and all supporting buildings (shops, warehouse, etc.)?” Then, the manufacturing space efficiency was calculated by dividing the modules per week by the plant size. This measure captures how well the plant space is utilized.

### Results

This section presents the results and statistical analysis from the survey of industrialized homebuilders. The presentation of the findings is grouped into two major subsections, which include the following: (1) descriptive characteristics, including basic statistics of the survey, and (2) correlation and regression analysis to determine the impact of customization on a plant’s operational performance.

1. **Descriptive characteristics.** Participating plants were asked to describe their product on the basis of the allowable level of customization (e.g., no customization, minor floor plan changes, extensive floor plan change, and totally custom/new sheet of paper) offered. The distribution of the primary level of customization offered by participating plants is as follows: 47 (33%) plants offered no customization, 56 (40%) offered minor changes, 24 (17%) offered extensive changes, and 5 (4%) offered totally custom. The primary level of customization for a plant refers to the category with the highest percentage; 9 (6%) plants were not included because of a tie for primary level.

Participating plants also documented the number of active continuous improvement programs and pay incentive programs provided to their employees in the past year. Most plants had at least one continuous improvement program (97 or 72%) and 56 (42%) had at least one active pay incentive program for their employees.

A summary of participating plant’s operating characteristics is shown in Table 1. Only the 132 builders responding to Q1 are included in subsequent analyses. Results from Table 1 show that plant capacity is smaller for firms with higher customization, and the number of backlog modules does not seem to change with the level of customization.

A summary of the participating plant’s operational performance, which answered Q1 on customization level, is shown in Table 2. Only the 132 builders responding to Q1 are included in subsequent analyses. Results from Table 2 show that annual labor turnover seems to be almost half for firms that offer totally customized homes compared to any of the other types of customization.

The standard deviation associated with the mean numbers in Tables 1 and 2 are large in some cases because the data for each variable is fairly widespread for all the customization categories. Therefore, interpretation of these results should be done with precaution.

2. **Correlation and regression analysis.** This section summarizes the results from the analysis of operational performance versus product customization. The purpose of this analysis is to

### Table 1. Summary of Mean (Standard Deviation) Operating Characteristics

<table>
<thead>
<tr>
<th>Homebuilder operating characteristics</th>
<th>Mean (SD): No customization (n = 47)</th>
<th>Mean (SD): Minor customization (n = 56)</th>
<th>Mean (SD): Extensive customization (n = 24)</th>
<th>Mean (SD): Totally custom (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant size (m²)</td>
<td>12,263 (6,066)</td>
<td>13,597 (8,351)</td>
<td>11,997 (4,569)</td>
<td>8,282 (3,665)</td>
</tr>
<tr>
<td>Number of main-line workstations</td>
<td>22 (8)</td>
<td>25 (14)</td>
<td>22 (7)</td>
<td>19 (5)</td>
</tr>
<tr>
<td>Plant capacity (modules produced/week)</td>
<td>32 (17)</td>
<td>31 (18)</td>
<td>22 (12)</td>
<td>16 (10)</td>
</tr>
<tr>
<td>Modules produced/year</td>
<td>1,479 (860)</td>
<td>1,423 (897)</td>
<td>1,063 (523)</td>
<td>756 (448)</td>
</tr>
<tr>
<td>Homes produced/year</td>
<td>886 (482)</td>
<td>745 (492)</td>
<td>5,267 (339)</td>
<td>267 (201)</td>
</tr>
<tr>
<td>Annual sales</td>
<td>$31 million (17)</td>
<td>$31 million (16)</td>
<td>$24 million (10)</td>
<td>$20 million (14)</td>
</tr>
<tr>
<td>Total annual labor cost</td>
<td>$4.21 million (2.86)</td>
<td>$4.43 million (2.76)</td>
<td>$3.93 million (1.70)</td>
<td>$2.8 million (1.76)</td>
</tr>
<tr>
<td>Number of modules in backlog</td>
<td>87 (116)</td>
<td>132 (179)</td>
<td>69 (82)</td>
<td>149 (173)</td>
</tr>
<tr>
<td>Annual number of accidents</td>
<td>26 (18)</td>
<td>26 (19)</td>
<td>30 (20)</td>
<td>21 (19)</td>
</tr>
<tr>
<td>Annual service cost</td>
<td>$1.05 million (1.05)</td>
<td>$1.26 million (1.09)</td>
<td>$97,000 (0.66)</td>
<td>$47,000 (0.40)</td>
</tr>
</tbody>
</table>
Identify statistical significance between operational performance metrics and the level of product customization offered to the customer.

Table 3 provides the correlation and means for different constructs, including product customization and operational performance measures. Table 3 shows that none of the independent variables have a significantly high correlation (i.e., above 0.70) which could have indicated multicollinearity problems in the data set. In addition, it shows that direct labor cost per sales dollar is correlated with customization and number of models (e.g., floor plans). It also shows that customization has insignificant correlation with the number of models offered. To cross-check this conclusion, variance inflation factors (VIF) and condition indices diagnostic tests were performed. The highest values for VIF and condition indices among all the four regression models were 1.60 and 5.65, respectively. This confirmed that there were no major collinearity problems (Mason and Perreault 1991).

**Hypothesis 1: Production Efficiency Declines with Increasing Customization**

The first hypothesis (H1) relates the impact of level of customization on a plant’s operational performance, a regression analysis was conducted. For this analysis, two different regression models were developed.

1. **Model 1:** Customization as the independent variable and labor cost per sales as the dependent variable

   \[ \text{labor cost per sales} = \beta_0 + \beta_1 \text{customization} + \beta_2 \text{number of models} + \text{error} \]  

2. **Model 2:** Customization as the independent variable and manufacturing space efficiency as the dependent variable

   \[ \text{manufacturing space efficiency} = \beta_0 + \beta_1 \text{customization} + \beta_2 \text{number of models} + \text{error} \]  

The number of different models or floor plans produced by homebuilders was used as an appropriate control variable for both regression models. As the number of models is one of the dimensions of product choice, it was used as a control variable to evaluate customization on a more controlled setting. Product choice had two main dimensions, which include the following: the number of floor plans offered (variety) and the degree of customization (e.g., dimensional changes and finishes) permitted. For instance, a homebuilder might offer a large number of floor plans, but limit the degree of customization for each.

The results in Table 4 show that customization has a significant impact on the operational performance. In the first model, customization has a significant positive impact on direct labor cost per sales dollar \((p < 0.01)\). Thus, a significant rise in the labor cost per sales dollar, with the increase in customization, is shown. In the case of the second model, results showed that customization has a significant negative impact on manufacturing space efficiency \((p < 0.01)\). In other words, plants that offer more customization tend to be less efficient in their use of manufacturing space.

**Table 2. Summary of Mean (Standard Deviation) Operational Performance**

| Homebuilder operational performance | Mean (SD):  
|-----------------------------------|----------|
| No customization \((n = 47)\) | Mean (SD):  
| Minor customization \((n = 56)\) | Mean (SD):  
| Extensive customization \((n = 24)\) | Mean (SD):  
| Totally custom \((n = 5)\) |  
| Labor cost/sales | 0.14 (0.05) | 0.15 (0.05) | 0.16 (0.05) | 0.16 (0.03)  
| Employee satisfaction (annual labor turnover [%]) | 68 (42) | 60 (35) | 62 (40) | 32 (24)  
| Customer satisfaction (%) | 90 (5) | 89 (6) | 85 (7) | 93 (N/A)  
| Manufacturing space efficiency (current production/plant size in million m²) | 24 (14) | 20 (12) | 16 (10) | 17 (10)  

*Only one usable observation for this category.

**Table 3. Summary of the Pearson Correlation Analysis**

<table>
<thead>
<tr>
<th>Labor cost/sales</th>
<th>Customization</th>
<th>Quality improvement programs</th>
<th>Incentive pay program</th>
<th>Employee satisfaction</th>
<th>Customer satisfaction</th>
<th>Manufacturing space efficiency</th>
<th>Number of models</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.20a</td>
<td>0.080</td>
<td>0.118</td>
<td>–0.16</td>
<td>–0.021</td>
<td>0.47a</td>
<td>–0.17a</td>
</tr>
<tr>
<td>0.07</td>
<td>0.00</td>
<td>0.07</td>
<td>0.07</td>
<td>–0.09</td>
<td>–0.16</td>
<td>0.01</td>
<td>0.12</td>
</tr>
<tr>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.07</td>
<td>0.12</td>
<td>0.21a</td>
<td>0.13</td>
<td>–0.1</td>
</tr>
<tr>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*aCorrelation is significant at 0.05 level (2-tailed).

**Table 4. Parameter Estimates from Regression Models**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1 parameter estimate ((DV = \text{labor cost/sales}))</th>
<th>Model 2 parameter estimate ((DV = \text{manufacturing space efficiency}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.130a (0.009)</td>
<td>264.92a (22.20)</td>
</tr>
<tr>
<td>Customization</td>
<td>0.044a (0.017)</td>
<td>–136.78b (50.76)</td>
</tr>
<tr>
<td>Number of models (floor plans)</td>
<td>0.001 (0.001)</td>
<td>0.173b (0.10)</td>
</tr>
<tr>
<td>R-square</td>
<td>0.056</td>
<td>0.067</td>
</tr>
</tbody>
</table>

Note: Standard errors are given in parentheses.  
\(a p < 0.01\).  
\(b p < 0.1\).  

Hypothesis 2: Employee Satisfaction Differs with the Level of Customization Offered, High Customization Should Lead to Higher Employee Satisfaction

The second hypothesis (H2) relates to how the level of customization of homes has an impact on employee satisfaction. Again, a regression analysis was conducted to explore this relationship. In this analysis, employee satisfaction is defined as a measure of the rate of employee turnover. Quality improvement programs and incentive pay programs were used as control variables in this analysis. Table 5 provides the details of the regression model. Customization and incentive pay programs were found to be negatively significant ($p < 0.01$ and $p < 0.05$, respectively). Thus, this implies that with higher levels of customization one will see a decrease in labor turnover. Hence, customization will lead to higher employee satisfaction as measured by lower labor turnover.

Hypothesis 3: Customer Satisfaction Differs with the Level of Customization Offered, High Customization Should Lead to Higher Customer Satisfaction

The third hypothesis (H3) relates to the level of customization of homes with the impact on customer satisfaction. A regression analysis was conducted to explore this relationship. Similar to the model for H2, here quality improvement programs were also used as control variables. Table 6 provides the regression model results in detail. Although the writers predicted the positive impact of customization on customer satisfaction, they found that customization was negatively significant ($p < 0.01$) and in contrast to this, the impact of the control variable quality improvement programs was positively significant ($p < 0.01$) to customer satisfaction.

Discussion

In general, operational performance deteriorates with an increase in choice. Therefore, industrialized housing manufacturers (and their customers) have not reached the ideal of mass customization and pay a price for offering more choices to the customer. The subsequent section discusses how increased product customization affects the metrics found to be significantly related in direct labor cost per sales, manufacturing space efficiency (plant size per current production), customer satisfaction, employee satisfaction (as measured by employee turnover), and quality improvement programs, which might be impacted by increased product choice.

Product variation manifests itself in several ways on the manufacturing floor. More and different components are used to perform the same function. The different components are often fabricated and installed using different tools and methods. Custom configuration, even of common components, can increase complexity. Extra time is required to think through the process and then perform the actual work. The reduction in repetition makes it harder to improve on the learning curve. If errors are made, productivity is further reduced by rework. These factors obviously drive labor productivity metrics, such as labor costs per sale. Similar to the findings of Qiao et al. (2004), this study found that extra labor is needed to compensate for product and order variations.

Excess inventory is also a problem faced by plants that offer more choice. This is consistent with the Qiao et al. (2004) findings that indicated that extra inventory is needed to compensate for product and order variations. The need to warehouse and stage a greater variety of components may also increase plant size. Plant size per current production rate may also be impacted by the longer line cycle time (lower production rate) typically associated with highly customized homebuilding. As some elements of the plant (e.g., floor, wall, and roof jigs) require a minimum footprint, this larger square footage is amortized over fewer homes. Plants that offer more customization tend to be less efficient in their use of manufacturing space. This is owing to the fact that production rates for those plants are typically lower than those of factories offering less product customization. Therefore, their square footage is amortized over fewer homes, resulting in lower space efficiency.

Some builders approach customization by offering a high variety of floor plans and options as their business strategy. However, this strategy can backfire. From a customer’s perspective, they might become overwhelmed by the complexity and number of choices. From a builder’s perspective, Blecker et al. (2005) argues that product choices should be restricted to as few as possible to achieve cost efficiencies. Results showed that high level of customization of homes leads to lower customer satisfaction. This contradictory result between customization and customer satisfaction can have a plausible explanation on the basis of the “disconfirmation theory” from the marketing literature. This theory on the basis of the expectancy-disconfirmation paradigm states that the consumers judge satisfaction by comparing previously held expectations with perceived product performance. If the performance is above (or below) expectations, positive (or negative) disconfirmation occurs and an increase (or decrease) in satisfaction is expected (Oliver 1980). The marketing literature also states that different consumer segments have different levels of expectations (Ganesh et al. 2000). For example, the consumers who buy customized laptops usually have higher expectations about the quality of performance of the product than consumers who purchase standard laptops. Extending these theoretical arguments to this study, the writers can state that in the housing industry there are also several segments of customers on the basis of the level of housing customization requirement. The consumer with the requirement of a high level of customization will have higher expectations than the consumer with the requirement of lower level of customization, and obtaining a positive disconfirmation of these higher expectations is very difficult. Thus, because of these higher levels of expectations, high customization can lead to lower customer satisfaction. Results also showed that quality improvement programs will lead to improvement in customer satisfaction. Typically, companies with quality control systems that are working well are able to identify and correct in-plant defects.

**Table 5. Parameter Estimated from Regression Models**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameter estimate</th>
<th>( DV = ) employee satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>79.86(^a) (6.45)</td>
<td></td>
</tr>
<tr>
<td>Customization</td>
<td>-28.64(^b) (14.6)</td>
<td></td>
</tr>
<tr>
<td>Quality improvement programs</td>
<td>1.79 (4.16)</td>
<td></td>
</tr>
<tr>
<td>Incentive pay program</td>
<td>-9.14(^b) (3.53)</td>
<td></td>
</tr>
<tr>
<td>R-square</td>
<td>0.079</td>
<td></td>
</tr>
</tbody>
</table>

Note: Standard errors are given in parentheses.  
\(^a\) $p < 0.01$.  
\(^b\) $p < 0.05$.

**Table 6. Parameter Estimated from Regression Models**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Parameter estimate</th>
<th>( DV = ) customer satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>90.42(^a) (1.02)</td>
<td></td>
</tr>
<tr>
<td>Customization</td>
<td>-10.97(^a) (2.67)</td>
<td></td>
</tr>
<tr>
<td>Quality improvement programs</td>
<td>3.43(^a) (0.65)</td>
<td></td>
</tr>
<tr>
<td>R-square</td>
<td>0.238</td>
<td></td>
</tr>
</tbody>
</table>

Note: Standard errors are given in parentheses.  
\(^a\) $p < 0.01$.  
\(^a\) $p < 0.01$.
Hence, the results revealed that companies with an active quality improvement program have higher customer satisfaction owing to fewer quality issues. Similarly, Sievanen et al. (2000) highlighted the importance of quality controls for companies offering customization to prevent passing defects to the customer and in turn prompting customer dissatisfaction. This may also explain higher employee satisfaction with companies offering more custom homes. Therefore, customization and paid incentive programs will lead to higher employee satisfaction and lower labor turnover.

Conclusions and Future Research

The results of the industry survey revealed that most U.S. industrialized homebuilders (40%) tend to offer minor changes (e.g., stretches or flips of the base model floor plan) of their standard home models. This strategy is similar to the tailored customization in which a basic product is customized in the fabrication stage, as described by Barlow et al. (2003) on his investigation of Japan’s industrialized housing industry. In general, operational performance was found to deteriorate with an increase in customization. Therefore, the industrialized housing manufacturers surveyed have not reached the ideal of mass customization (i.e., effectively managing the production complexities of customization) and are paying a price for offering more choices to their customers. These results revealed that plants offering increased customization are likely to suffer poorer direct labor productivity (as measured by direct labor costs per sale), lower space efficiency, less-satisfied homebuyers, and higher employee satisfaction (as measured by labor turnover).

Although, contrary to the writer’s expectations, the results for H3 indicate a negative impact of customization on customer satisfaction. The writers offer some plausible reasons for this observation, which include the following: (1) customization of the product results in operational complexities that can result in longer completion time of the final product, which can also lead to lower customer satisfaction, and (2) usually buyers of customized homes tend to have higher expectations from the finished product than the buyers of standardized homes and it becomes more difficult to satisfy these expectations, leading to negative disconfirmation. This results in buyers of customized homes providing lower satisfaction ratings than buyers of non-customized homes.

Homebuilders need to balance the trade-off between increasing customer satisfaction through customization and increasing the company’s productivity through standardization. One approach that is being used to address the industry’s challenges described previously is that of implementing lean production techniques (Nahmens 2007). Results show that in some respects the industrialized housing industry is already somewhat lean (e.g., it works on the basis of customer pull and continuous process flow and maintains little inventory). However, on a broader level, the application of lean principles would require a major cultural change (e.g., improved quality culture and the use of technology that serves people and processes). Results also show that the application of lean principles can be effectively put into practice in plants offering different levels of product customization (e.g., homebuilders producing highly customized homes and homebuilders producing standard homes with predetermined sets of options) (Nahmens and Mullens 2009). However, both were able to effectively accommodate choice within their department/process where lean strategies were implemented.

Mass customization remains a possible strategy, but further research is needed to explore different process improvement strategies that could mitigate current production inefficiencies.

These findings can help homebuilders pinpoint areas in which to focus improvement efforts and become more efficient in offering increased product choice. More specifically, findings from the survey will contribute to a better understanding of the applicability of mass customization strategies in the industrialized housing industry and it is expected that they will provide useful information to builders interested in addressing specific customer needs while managing the operational complexities resulting from product variety.

Some limitations to the study results must be noted. The findings that emerged from the survey are limited to the customization levels and operational performance metrics included. For example, employee satisfaction was not measured directly because of logistical constraints, but rather the rate of annual labor turnover was used as a proxy measure for employee satisfaction. It was found that the lower the percentage of employees leaving the company, the higher the percentage of employee satisfaction with their current job. However, there could be other constraints associated with switching jobs, such as personal growth, achievements, responsibilities, and recognition (Herzberg et al. 1959), work situation, diversity, and level of challenge on the job (George and Jones 2008). Similarly, logistical constraints prevented the direct collection of customer satisfaction data, yet this was provided by the respondent company via a global assessment from data collected from their internal customer satisfaction surveys. Although this may be a source of concern, the nature of the data collected via an industry alliance whose focus is on addressing the needs of the industry is expected to reduce the risk of overly-positive self-reports. The findings that emerged from this study are enlightening, but limited to the data collected. Future work may expand the analysis by considering other factors in the degree of customization equation such as change in features and/or finishes, point of customer involvement, and type of modularity, as suggested by Duray et al. (2000), and the use of other data collection methods. Another very important factor for future research is the fact that customization increases production costs (e.g., because of changes in layouts or the use of materials that required more complex construction methods). Hence, it is worth exploring any differences in profit margins among builders offering various levels of customization.

References
