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WHAT DETERMINES THE DEGREE OF PRODUCT CUSTOMIZATION? AN EMPIRICAL INVESTIGATION

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Abstract: *The external environment is of primary importance in determining the strategic decisions that a company intends to pursue, which in turn affect the organizational design choices. The degree of product customization that a firm provides to its customer is widely recognized as a key strategic decision in the context of mass customization. However, the external environmental factors that determine the degree of product customization have yet to be investigated empirically. To narrow this research gap, the present paper empirically examines the impacts of three external, environmental factors, namely competitive intensity, heterogeneity of customer demands and dynamism of customer demands, on the degree of product customization using survey data from 195 manufacturing plants in three industries and eight countries. The paper identifies the dynamism of customer demands as the key factor that pushes firms to increase the degree of product customization they provide to their customers.*

Key Words: ***Mass Customization, Degree of product customization, External environment, Survey research.***

1. INTRODUCTION

Mass customization, meant as providing customized products and services that fulfill each customer's idiosyncratic needs without considerable trade-offs in cost, delivery, and quality [1-3], continues to arouse widespread interest among both practitioners [4] and academic researchers [5, 6]. Since the introduction in literature of the mass-customization concept different types of mass-customization strategies have been distinguished [2] and, over time, several criteria have been proposed to classify these strategies [e.g., 7, 8]. The most commonly cited criterion, either alone or in combination with others, is the degree of product customization (DPC) that a firm provides to its customers [e.g., 2, 9]. The DPC is a key decision for a company pursuing a mass-customization strategy [7] and is related to the point of initial customer involvement along the value chain. A greater DPC means that customers are involved earlier along the value chain for a greater number of customer orders [10, 11].

The DPC, as a strategic decision, can be influenced by internal and external contingency factors. Among others, the external environment is of primary importance in determining the strategic decisions that a company intends to pursue, which in turn affect the organizational design choices [12].

Although mass customization has been recognized as a suitable answer to a highly competitive environment [13, 14], with very heterogeneous and hard to predict customer demands [15, 16] and DPC is the primarily strategic decision in a mass-customization context, there are no studies linking these environmental factors with the strategic decision on the DPC. Therefore, the paper aims to empirically investigate the links between three environmental factors (competitive intensity, heterogeneity of customer demands and dynamism of customer demands) and the DPC that the company offers to customers. The paper identifies the dynamism of customer demands as the key factor that pushes firms to increase the DPC they provide to their customers.

2. THEORETICAL BACKGROUND AND RESEARCH HYPOTHESES

2.1. Mass customization and the degree of product customization

Mass customization denotes an organization's ability to provide customized products and services that fulfill each customer's idiosyncratic needs without considerable trade-offs in cost, delivery, and quality [1-3]. The most important strategic decision for a company that wants to pursue a mass-customization strategy concerns the DPC that the company provides to its customers [7], which is related to the point of initial customer involvement along the value chain [10].

According to Lampel and Mintzberg [9] if the customer order influences a specific activity of the value chain, then it will also influence the content of the interdependent downstream activities. Moving product customization back along the value chain gives rise to five different strategies [9, 17]:

- *Pure standardization* (i.e., *no product customization / variety without customization)*, where the company provides a variety of products (even large) within which the customer can make a choice but product customization is not allowed;
- *Segmented standardization* (i.e., *customized distribution*), where the only activity influenced by the customer requirements is product distribution;
- *Customized standardization* (i.e., *customized assembly*), where customer requirements influence the assembly activities but not the manufacturing and design process;
- *Tailored customization* (i.e., *customized fabrication*), where customer requirements influence the manufacturing activities but not the design process;
- *Pure customization* (i.e., *customized design*), where customer requirements influence the value chain from the design phase.

By classifying a manufacturing company with one of these five strategies means that all the customer orders a company fulfills in a given time period fall into the selected type of strategy. However, in industrial practice companies sometimes pursue hybrid strategies [e.g., 18], combining different customization strategies for different customer orders. For instance, this may happen because different items of a company's solution space follow different customization strategies, consistent with Giesberts and van der Tang's [19] notion of assortment hybridity. Consequently, a higher DPC captures the fact that customers are involved at an earlier stage of the value chain for a greater number of customer orders [10, 11].

2.2. External environment

The external environment has long been acknowledged as an important contingency factor [e.g., 20, 21] and it is a primarily source of uncertainty for companies [14]. Environmental uncertainty is defined as a general lack of information in the decision making process [14, 22]. The literature has argued that mass customization is a viable approach in response to an environment characterized, on one hand, by a strong competitive pressure in a growing number of industries and, on the other hand, by an increasingly changing and heterogeneous nature of customer demand [2]. However, there is little empirical work that has investigated this claim [14]. Moreover, given that DPC is a fundamental strategic variable in pursuing mass customization, studies that link these environmental factors with the strategic choice on the DPC are lacking.

Pine [2] indicated two main categories of environmental factors that determine the market turbulence, which in turn would determine the company transition from mass production to mass customization: the structural factors and the demand factors. The structural factors reflect the nature of the industry and, specifically, the competitive intensity faced by a company that operates in a given industry. The demand factors reflect the nature of customer demand and, in particular, the degree of uncertainty that the company faces in the satisfaction of customer needs.

The competitive intensity is defined as the level of competition that a company has to face within its primary industry [14, 23]. This factor has always been indicated as an important driver of the decision to implement a mass-customization strategy, since the introduction of the mass-customization concept in the literature [2, 24]. In a competitive scenario characterized by the increasing global competition, the introduction of new technologies, the reduction of product life cycles and the growing demand for a greater product variety, companies can no longer compete on standardized products and services [13, 14]. Therefore, this increasing competitive intensity led to the need to pursue strategies focused on individual customer needs in many industries [7, 14]. Consequently, the following research hypotheses is posited:

Hypothesis H1: The competitive intensity has a positive effect on the DPC.

With regard to the uncertainty of the customer demand, it is worth noting that that the uncertainty of the environment has two fundamental dimensions: the complexity of the environment and the dynamism of the environment [22]. The environmental complexity is defined by Duncan [22] as the number of environmental factors to consider in the decision-making process. The larger the number of factors to consider, the more complex is the environment and, consequently, the greater is the uncertainty perceived by the decision maker. An important driver of the complexity of the environment, in which a company operates, is the heterogeneity of customer demand served by that company, namely the extent to which the demands of its customers are differentiated. The heterogeneity in customer demands can only be met by providing a greater degree of product customization [2]. Consequently, the following research hypotheses is posited:

Hypothesis H2: The heterogeneity of customer demands has a positive effect on DPC.

According to Duncan [22], the second dimension of the environmental uncertainty is the dynamism of the environment, defined as the rate of change of the factors to be considered in decision making. The more the number of the factors changes quickly and in an unpredictable manner [25], the more dynamic is the environment [14] and, consequently, the greater is the uncertainty perceived by the decision maker. An important driver of the dynamism of the environment, in which a company operates, is the dynamism of customer demand served by that company, defined as the rate of change in demand [14, 26]. When the demand is stable, a company is able to predict customer demands and its product offer will be able to meet the customer needs without having to design tailor-made products [14, 27]. On the other hand, when the demand changes very quickly and is difficult to predict, companies are forced to increase the degree of product customization to meet not-forecasted demands of customers and, therefore, to design and manufacture new products not yet incorporated into the solution space of the company. Accordingly, the following research hypotheses is posited:

Hypothesis H3: The dynamism of the customer demands has a positive effect on the degree of product customization.

2.3. Control variables

The control variable included in the analysis is the type of customers served by the company (end consumers or industrial enterprises). Supplying an industrial market is shown in the literature as a factor that pushes to offer a higher degree of product customization [28]. Effectively, companies that respond to the market with an engineer-to-order (ETO) mode, thus offering a very high degree of customization, are typically companies that serve industrial customers, which provide capital goods such as machinery and equipment [29].

With the discussion of the control variable included in this study, the presentation of the research framework is complete. The proposed model linking the competitive intensity, the heterogeneity of customer demands, the dynamism of customer demands and the DPC is graphically depicted in Fig. 1.

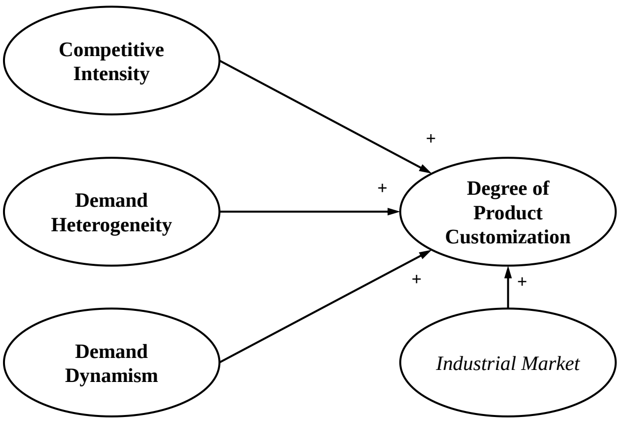

Fig.1. *Conceptual model linking three environmental factors and the degree of product customization*

3. METHOD

3.1 Data description

The data used for the empirical analysis were taken from the third round of the High Performance Manufacturing (HPM) project, a large-scale survey aimed to investigate manufacturing practices, processes and performance [30]. Twelve different questionnaires were developed by HPM researchers, which were directed to as many different respondent categories. The survey items were divided between the questionnaires in order to obtain information from the respondents who were most knowledgeable. The respondent categories included production workers, supervisors and various managers, such as the production control manager, the human-resources manager and the plant manager.

To maximize response rate, HPM researchers first solicited plants participation and then sent the questionnaires to those plants that had agreed to participate. In return for participation, each plant received a detailed report comparing its manufacturing operations profile to those of other plants in its industry. With this approach, the response rate was approximately 65% in each country, thus reducing the need to check for non-response bias [1, 31]. Additional details of the data collection procedures can be found in Schroeder and Flynn [30].

Owing to missing responses to the survey items necessary to determine the DPC, which responses were missing completely at random based on Little's test, 43 plants were removed in this study. The sample used in this study consists of 195 plant from three industries (machinery, electronics and automotive suppliers) and eight countries (USA, Japan, South Korea, Austria, Finland, Germany , Italy and Sweden). The sample profile is reported in Table 1.

Table 1. *Sample profile*

	INDUSTRY			
COUNTRY	**Electronics**	**Machinery**	**Auto Suppliers**	**Tot.**
Austria	9	5	2	**16**
Finland	13	4	10	**27**
Germany	7	9	16	**32**
Italy	10	10	7	**27**
Japan	9	11	6	**26**
South Korea	6	8	8	**22**
Sweden	7	8	7	**22**
USA	8	8	7	**23**
Total	**69**	**63**	**63**	**195**

3.2. Measures

The environmental drivers were measured through reflective scales at one or more items. For each item respondents indicated to what extent they agreed or disagreed with the corresponding statement on a seven-point Likert scale anchored at the extremes " strongly disagree " (1) and " strongly agree " (7). Two items reflecting the competitive pressure in the company industry measured the competitive intensity scale (Competitive Intensity). A single reverse-coded item that captures the homogeneity of customer needs measured the heterogeneity of customer demands (Demand Heterogeneity). Two items measured the dynamism of customer demands (Demand Dynamism) covering, on one hand, the fact that the needs and demands of customers change very quickly and, on the other hand, the fact that product demand is unstable and unpredictable. Finally, the DPC has been measured by the objective measure defined by equation (1).The DPC is measured as the weighted average of the percentages of customer orders that, at a given plant, fall into the following five strategies: namely, customized design (CDE%), customized fabrication (CF%), customized assembly (CA%), customized distribution (CDI%), and no customization (NC%).

$$DPC = \frac{CDE_{\%} \times 4 + CF_{\%} \times 3 + CA_{\%} \times 2 + CDI_{\%} \times 1 + NC_{\%} \times 0}{400} \quad (1)$$

Finally, supplying industrial customers (Industrial Market) has been measured by a dummy variable equal to 1 if the company provides its products to the industrial market (see Table 2).

4. RESULTS

Partial Least Squares (PLS) was chosen to perform the data analysis for this study [32]. The main reason for using PLS rather than covariance-based structural equation modeling (CBSEM) (such as LISREL) is that the estimation of a CBSEM may have some identification criticalities of the measurement model. The minimum condition of identifiability of a CBSEM measurement model is that the number of non-redundant elements in the covariance matrix of the variables is greater than or equal to the number of parameters to be estimated [33]. In the model analyzed in this study, there are variables modeled by a single item. This fact violates the minimum condition of identifiability and it is necessary to arbitrarily constrain some parameters; in the specific case, to constrain arbitrarily the measurement error variance of the non-objective variable measured by a single item. Since the PLS technique is free from identification constrains, it is possible to estimate causal models without the constraints that the CBSEM involves [34]. Therefore, to overcome the identification problems that would occur in the case of CBSEM, PLS was used in the data analysis, which is also advantageous with respect to the multiple regression because it is able to estimate models containing latent constructs reflected and/or formed by multi-item scales [32, 34].

SmartPLS 2.0 M3 was used to evaluate the measurement model and the structural model. A bootstrapping estimation procedure, in which 500 random observation samples were generated from the original data set, was used to analyze the significance of the scale factor loading in the measurement model and the significance of the path coefficients in the structural model [34]. Before analyzing the data with PLS, all the variables were standardized across country and industry in order to rule out their potential effects, in line with several previous studies [e.g., 18, 35, 36-38].

4.1. Measurement quality

The PLS technique was used to evaluate the properties of the multi-item scales measurement model such as reliability, the undimensionality, convergent validity and discriminant validity [39].

Table 2: *Measurement model*

Measurement item	Std path loading
Competitive intensity (PE, PM, PS)*	
CR=0.86, AVE=0.75	
CI1: We are in a highly competitive industry	0.72
CI2: Our competitive pressures are extremely high	1.00
Demand Heterogeneity (PD, PE, PS)*	
CR=1, AVE=1	
DH1: All of our customers desire essentially the same products (reversed coded)	1
Demand Dynamism (PD, PE, PS)*	
CR=0.70, AVE=0.57	
DD1: The needs and wants of our customers are changing very fast	0.45
DD2: The demand for our plant's products is unstable and unpredictable	0.97
Degree of Product Customization (PE)*	
CR=1, AVE=1	
DPC1: See equation (1)	1
Industrial Market (PD)*	
CR=1, AVE=1	
BB1: Industrial market	1

** Respondent codes (PD: member of product development team; PE: process engineer; PM: plant manager; PS: plant superintendent)*

The reliability of the scales was assessed in terms of the composite reliability (CR) [39]. The composite reliability values of multi-item scales of measurement model are 0.86 and 0.70, so equal and higher than the recommended threshold of 0.70 [40], demonstrating adequate reliability of the measurement scales.

The unidimensionality and convergent validity of the multi-item scales were evaluated in terms of average variance extracted (AVE) [39]. The AVE values of the multi-item scales of the measurement model are of 0.75 and 0:57, both above the threshold recommended 0.50, which demonstrates adequate convergent validity. Moreover, all the factor loading of these scales are significant and greater than 0.5, with the exception of an item of the construct Demand Dynamism that is slightly below this threshold, confirming again adequate unidimensionality and convergent validity [33, 34, 41].

Discriminant validity of the scales was assessed by comparing the square roots of the AVE of each construct with the correlations between the focal construct and every other constructs. Discriminant validity is indicated by the square root of AVE of one construct greater than the correlation between the construct and the other constructs [39]. Table 3 shows the correlations between the constructs and the square root of AVEs. The comparison between the square root of the AVE, shown on the diagonal of the matrix, and the inter-correlations between this construct and the others, shown off the diagonal of the matrix, suggests discriminant validity for each construct.

Table 3: *Inter-construct correlations*

	Correlations (PLS results)				
	1	**2**	**3**	**4**	**5**
1 - Competitive Intensity	**0.87**				
2 - Demand Heterogeneity	0.02	**1**			
3 - Demand Dynamism	0.19	0.06	**0.75**		
4 – DPC	0.03	-0.02	0.20	**1**	
5 - Industrial Market	-0.06	0.00	-0.02	0.12	**1**

Note: The squared root of the average variance extracted (AVE) is shown on the diagonal of the matrix in bold; the inter-construct correlation is shown off the diagonal.

4.2. Structural model

The path coefficients and their statistical significance of the structural model are reported in Table 4.

Table 4: *Structural model path coefficient estimates*

Path	**Path coefficient**	
Competitive Intensity -> DPC	-0.003	NS
Demand Heterogeneity -> DPC	-0.033	NS
Demand Dynamism -> DPC	**0.209**	*******
Industrial Market -> DPC	**0.127**	*****

Levels of significance:
*NS: not significant ; * p < 0.10; ** p < 0.05; ***p < 0.01*

As shown by the path coefficients, as regards the impacts of environmental drivers on DPC is noted that:
• The impact of the dynamism of the customer demands on DPC is positive and statistically significant (b = 0.209, p <0.01);
• The impact of the competitive intensity and the heterogeneity of customer demands on DPC is not statistically significant.
As regard the impact of the control variable on DPC is noted that companies that serve industrial customers provide higher DPC (b = 0.127, p <0:10).
The model explains 6% of the variance (R^2) of DPC, and this analysis shows that the crucial environmental factor in the adoption of a higher DPC is the dynamism of customer demands, thus supporting only hypothesis H3. The analysis does not provide empirical support to hypotheses H1 and H2, since no significant path coefficients exist between competitive intensity and DPC and between heterogeneity of customer demands and DPC.

5. DISCUSSION AND CONCLUSION

This study contributes to the understanding of the drivers of the DPC to be provided to customers, by developing and empirically testing hypotheses on the impact of three external environmental variables (competitive intensity, demand heterogeneity and demand dynamism) on DPC. The analysis conducted for this paper empirically supports only the hypothesis that the dynamism of customer demands is an environmental factor that determines an increase in DPC (H3). When a company faces an extremely changeable and unpredictable customer demand, characterized by increasingly requests for new and differentiated products, the company is forced to wait for the customer's order before beginning the design of the product. A very dynamic demand does not allow the company to design in advance all the possible variants of the product that the customer may require. On the other hand, the analysis conducted in this study does not support the hypothesis that the competitive intensity (H1) and the demand heterogeneity (H2) driver the increase of DPC. Indeed, in a highly competitive market or in a market characterized by heterogeneous demands, but stable over time, the customer demands can be forecasted and can be fulfilled by offering a high product variety but entirely designed in advance.

While contributing to both the academic literature and managerial practice, this study is not without limitations, which might be addressed in future research. The first limitation is related to the cross-sectional nature of the data set used in this study, which limits the ability to explore the causal relationship between environmental drivers and DPC. Therefore, a future research opportunity is to design a longitudinal study to assess these causal relationships over time. A second limitation of this study is derived from the use of secondary data to measure the constructs of interest. Therefore, future research should design an ad-hoc questionnaire for the investigation of the relationship between the environmental drivers and DPC, thus allowing the use of more articulated scales and with a greater number of items for measuring the constructs of competitive intensity, demand heterogeneity and demand dynamism.

6. ACKNOWLEDGEMENTS

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