Implementation of Mass Customization for competitive advantage in Indian industries: a structural equation model

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Abstract

The enduring fluctuations in market demand, exemplified by exceedingly unpredictable customer requirements have given rise to Mass customization, which is acquiring increasing prominence in production and operations management. Fostering on the foundation laid by erstwhile researcher Hart[1], who developed an analytical framework of four pillars of mass customization for organizations, the objectives of this research are to obtain additional discernments on the nature of linkage between the four pillars and MC, in addition to their impact on competitive advantage. The current work is an attempt to explore the mass customization ability of manufacturing organizations of Indian origin and its impact on organisational performance and to propose a comprehensive assessment and decision-making model for manufacturers to implement mass customization for competitive benefits. Literature support is expanded and validated using data collected through survey conducted among managers of various divisions of organization of Indian origin. The final sample contains 276 usable observations. Data analysis was performed expending structural equation modelling(Amos Graphics).

1 Introduction

The outbreak of COVID-19 has augmented the challenges to globalization and the International Business arena eliciting economic turbulence, global value chain disruptions, stimuli of nationalism, and protectionism[2]. The aggrandizement of a post-COVID-19 business paradigm necessitates motivating challenges to ensure competitiveness and will require rethinking[3]. Given the scenario, MC necessitates embracing strategies and create a manufacturing model that promotes flexibility, provides quick customer response, price-competitive products, product design as per customers’ needs, and attainment of business goals [4].

Several researchers have characterized mass customization as a production paradigm endowing profound strategic opportunities[5] with potentials of managerial response during a progressively uncertain, competitive, and intricate environment[6], having competitive positioning strategy in the marketplace[7] during the period exemplified by the introduction of innovative production technologies, increased global competitiveness, reduced product life cycles, and the customer need for more product diversity[8]. Organizations aiming to mass customize, on the other hand, will have hurdles in designing a system capable of acquiring and analyzing a wide range of complex and uncertain data [9]. The ability to manufacture mass customized goods is dependent on the ability of a corporation to use a range of production issues simultaneously, including quality, inventory, process technology, and human skills [5]. For effective application of their MC ability for competitive advantage, organizations must identify and exploit resources and skills effectively and efficiently[10]. This necessitates the development of a manufacturing model to identify the factors a manufacturer needs to consider for the effective implementation of MC in an organization.

Most of the research to enhance MC ability and to improve an organization's MC capabilities was carried out in the areas of organizational design and manufacturing practices or product and customer aspects

like quality management [11], product modularity [12], functional integration [13], information technology [14], work-design practices[15], operations and marketing functions[16], supply chain integration[17], organizational learning and process technology[18], organizational structure [19], CAD/CAE integrated customization product approach[20], product modularity on supply chain quality integration[21]customer integration [22], degree of consumers involved in the value chain[23].Some studies identified technology needed like Industry 4.0 [24], RFID-enabled real-time manufacturing execution system[25], additive manufacturing [26], Computer-aided manufacturing planning[27]. None of these preceding research analyzed the role of operational agility required for MC ability. Organizations entailing to implement mass customization to enhance market competitiveness require to improve the operational agility of the MC production model to increase the flexibility, speed, and efficacy of responding to unique client needs [28].

Some research identified the role of enablers in manufacturing[29][30], but used ISM technology which is solely dependent on the judgment and qualitative inputs of few experts and was used to build theory, and testing of theory using structured questionnaire and in a single analysis, estimates of multiple and linked dependency were needed. Research work conducted was region-specific or product/ sector-specific, or both like Chinese automotive suppliers[31], door sector in Poland[32], pigment company in Taiwan[33], Shoe manufacturing in India[30]. Based on the above research study, the following gaps were observed:

- Manufacturing sectors in India identifying the possibility of moving away from mass manufacturing and toward mass customization requires a manufacturing model to enhance competitive advantage and tide over competitors and needed to identify operational agility to enhance MC ability.

This study aims to create a manufacturing paradigm that allows for mass customization and hence provides a competitive edge. The purpose is to employ analysis to experimentally resolve gaps in MC theory, with a focus on India's manufacturing industry and how customer, process, competition, and organizational factors affect mass customization capabilities for competitive advantage. The foundation laid by Hart (1995) on building an analytical framework and described as the four pillars of mass customization was further analyzed by using a structural equation modeling (SEM), which is used to analyze data from 276 manufacturing companies of Indian origin.

The paper is organized as follows: Sect. 2 represents theoretical background and hypothesis development. Section 3 highlights the research methodology. Section 4 presents Analysis and results. Section 5 articulates the Results and Discussion. The managerial implication of the study is provided in Sect. 6. Section 7 conveys the limitation of the study and future research direction.

2. Theoretical Background And Hypothesis

The research is based on developing a manufacturing model for mass customization ability, as all operations in the product design, manufacturing, and delivery processes must be better coordinated and integrate[13]. To solve internal and external supply chain quality challenges, managers must use manufacturing and organizational design principles to improve mass customization capabilities [21]. Suppliers and customers amalgamation has a major impact on the agility and flexibility of an

organization, which is necessary for MC capabilities[34]. Tookanlou and Wong [35] identified mass customization as a promising technique that has grabbed the interest of practitioners and researchers due to its potential to help firms gain a competitive advantage, generate profits and minimize waste through on-demand production. The hypotheses offered in this study are based on the four pillars of mass customization proposed by Hart (1995) and further strengthened by investigating the relationship between MC ability for competitive advantage from the extant literature. The constructs, related measurement items are presented in Table 1.

2.1 Customer sensitivity: The uniqueness of customers' demands and consumer sacrifice for unmet needs are the primary drivers of customer customization sensitivity [1]. To create mass customization capability, organizations must improve their operational efficiency, which necessitates the interchange of information between customers, salespeople, and technical personnel [36]. Customers must transform their wants and demands into particular product requirements [22] by customizing, setting, matching, or altering a solution, limiting the solution space to options already represented in the system's fulfillment, and converting consumer co-design data into customer knowledge for strategic planning and innovation [37][38]. Customer input to establish features and pricing requirements of personalized products to meet consumers' particular requirements cheaply and promptly [39], and a study of consumer buying patterns[40] can contribute to success in this field. Quick customer response for the implementation of mass customization is built on a system that connects consumer voice to product design, customer relationship management, regular market surveys, and understanding client grievances for product improvement [41]. Thus, the following hypotheses were advanced:

Hypothesis H1

Customer sensitivity is positively related to MC ability

Table 1
Constructs, Measurement items with factor loads

Constructs	Measurement Items	Factor Loads	Cronbach's Alpha (> 0.70)	Item R-Square	CITC (> 0.30)
Customer Sensitivity	**CS1** Identify opportunities for customization	0.902	0.958	0.814	0.714–0.874
	CS2 Understand the uniqueness of customers' needs and create value	0.927		0.859	
	CS3 Analyze customers sacrifice for unmet needs	0.845		0.714	
	CS4 Provide ease of customer choice for decision making	0.883		0.780	
	CS5 Create value for the customer	0.926		0.857	
	CS6 Incorporate customer requirement during new design process	0.865		0.748	
Process Amenability	**PA1** Incorporate modularity in design, for part flexibility	0.825	0.924	0.681	0.635–0.784
	PA2 Develop compatible process technology	0.765		0.585	
	PA3 Develop production and distribution process for timely delivery	0.881		0.776	
	PA4 Develop supplier for co-design	0.872		0.760	
	PA5 Develop marketing competence for product promotion	0.863		0.745	
Competitive Environment	**CE1** Economic uncertainty	0.771	0.917	0.594	0562-O.835
	CE2 Market Turbulence	0.758		0.575	
	CE3 Company credibility and position in marketplace	0.851		0.724	
	CE4 Customer loyalty	0.868		0.753	
	CE5 Potential of competitors to react	0.873		0.762	

Constructs	Measurement Items	Factor Loads	Cronbach's Alpha (> 0.70)	Item R-Square	CITC (> 0.30)
Organizational readiness	**OR1** Cultural change in the organization	0.866	0.954	0.750	0.754–0.867
	OR2 Skill development of employees	0.924		0.854	
	OR3 Employee's involvement in product and process roadmap	0.869		0.755	
	OR4 Training to marketing team to capture and prioritize requirements	0.914		0.835	
	OR5 Top management support and leadership building	0.918		0.843	
Mass Customization Ability	**MC1** Product can be customized on large scale	0.848	0.908	0.719	0.647–0.782
	MC2 Product variety can be enhanced at same cost and quality	0.833		0.654	
	MC3 Product can be designed based on customers' requirements	0.862		0.740	
	MC4 Product can be delivered on stipulated time	0.830		0.689	
Competitive advantage	**CA1** Market share growth and Reaching financial goals	0.815	0.906	0.664	0.584–0.703
	CA2 Acquiring new customer	0.812		0.659	
	CA3 Increased sales volume/ Return on sales/revenue	0.846		0.716	
	CA4 Increased product variety	0.783		0.613	
	CA5 Reduce waste through on demand production	0.813		0.661	

2.2 Process Amenability: Enablers, marketing and strategy, design, production, and distribution are all part of this diverse region[1]. New technology must be integrated and coordinated with humans and organizations to successfully execute mass customization [42]. Flexible manufacturing techniques are required by MC to help businesses become first to market with unique, custom-made items. [43] to manage the complexity of mass customization [44]. Increasing product variety implies richer information flows, which in turn necessitates increased scheduling and coordination complications inside the organization [13][45], giving rise to increased information processing needs [13]. Organizations need to establish suitable information infrastructure to expedite regular communication and information with

suppliers, customers, and other stakeholders [46][29][42], to keep close communication with its supplier for design consideration[47], and determine interface specifications to ensure module combinability[14]. Encompassing suppliers in quality enhancement and new product improvement helps a company to tap into their capabilities and competencies, which can moderate new product development expenses and lead times while also minimizing component mismatches [48][49]. Collaboration with suppliers for new product development and standards by firms is vital since modules require consistent specification [21]. Modular product design is based on modular components that may be assembled into several end products [50] as well as the reuse of the same modules across several end products [51], resulting in increased product volume and variety [12]. Modularity primarily influences the desirability of products by developing tenuously connected modules that may be procured from vendors [32] and merged according to consumer requirements and manufacturing processes [52]. It is critical to maintain constant, direct contact with customers and involve them in the design process to incorporate values that are important to them into the design [32]. Managers, according to Zhang, Lettice, and Zhao[39], must communicate with consumers and suppliers at the same time to incorporate MC concepts throughout the design phase. The following hypotheses are based on the previous reasoning

Hypothesis H2

Process Amenability is positively related to MC ability.

2.3 Competitive Environment- Competitive environment, economic uncertainty, market turbulence, firm credibility and position in the marketplace, as well as consumer loyalty, are all elements to consider in the journey to mass customization [1]. Researchers have advocated that enterprises who change from mass production to the novel paradigm of mass customization will acquire a competitive benefit [8] due to the growing awareness of mass customization. Organizations require a greater diversity of supply to meet heterogeneous and changeable consumer demand, which upsurges the ambiguity in forecasting demand for each type of product. This causes scarcities, quality concerns, and extended lead times in supplier parts, which causes manufacturing delays and limits a company's capacity to mass customise[13]. To successfully adapt to altering market wants, MC capability development necessitates extraordinary levels of process flexibility and agility inside a company[53], as well as excellent internal integration across multiple roles. The conception of mass customization has been in practice to improve an organization's ability to respond fast to dynamic changes in the global marketplace [27]. This method cannot only improve resilience, preserve operations, and support personnel during economic downturns, but also maintain a competitive advantage and accelerate business growth[41]. The following hypothesis is proposed based on the above research findings:

Hypothesis H3

Competitive Environment *is positively related to MC ability.*

2.4 Organizational readiness: Organizational readiness demands a thorough examination of the organization's approaches, culture, and resources [54] to determine the extent of similarity between the

commercial opportunity offered by mass customization and the organization's capacity to profit on it [1]. To attain new and innovative forms of competitive advantage, enterprises must integrate, build, and reconfigure available resources to satisfy the expectations of a continually changing environment [17]. Before transitioning from a conventional mass production setup to a successful MC firm, enterprises must make significant changes to their historical mindsets and practices [55], since mass customization involves true change management initiatives in existing enterprises [37]. To resolve the hindrances faced by organizations while implementing mass customization, intensification of the training of designer and personnel reassignment needs to be considered for implementation of MC ability and enhancing their market competitiveness[28]. Organizational performance necessitates a group of workers with cross-functional skills to foster creativity and innovation throughout the entire value chain to improve MC's ability to achieve organizational goals [29]. Mass customization is presented as a marketing concept that allows for the acquisition of a large number of customers while providing the opportunity to personalize the product [56]. Hence organizations require to bring a cultural change, involve their workforce in all phases of MC implementation, upgrade and train employees for MC innovative ideas, train its marketing team to understand the desire of customer and market requirements that need to be converted into various MC aspects of design. Such organizational readiness brings about operational agility for MC adaptation and implementation. Organizations having unique operational capabilities with collaborative relationships with the suppliers, flexible, innovative, and adaptive work culture has strong MC ability[29]. Tung, Baird, and Schoch [57] emphasized that top management's participation in problem resolution was crucial during crisis and conflict, therefore all across the execution phase, it was essential to simultaneously enhance production, process, and product on the strategic and tactical level, which might be a challenging assignment for top management.[40]. Effective leadership for analyzing future market potential, participation to ensure technical, economic, and personnel support, aid during obstructions, and strategic monitoring of MC projects and appraisal of their progress are the most important criteria for mass customization success[41]. Organizations that are flexible ensure mobility, agility, and adaptability, are more capable to reduce the response time to demand changes[58]. Companies that are self-sufficient, self-organized, linked with intelligent digitalization and forms of communication, and seem to have independent entity management teams, utilize additional supplier networks, guarantee better supply chains' capacity and access to external resources, have a protocol in place and diverse supply alternatives, and facilitate collaboration among supply chains are more ready for MC implementation. Thus, the following hypotheses are proposed:

Hypothesis H4

Organizational readiness is positively related to MC ability.

2.5 Mass customization ability- MC is becoming a more important strategic goal as competition grows and customers become more assertive[19]. The ability to manage change has the potential to improve operational, market, environmental, and financial performance[56]. When faced with fierce competition, many businesses want to improve their MC skills to outperform their rivals [6]. An organization's effective application of mass-customization gives a competitive edge in the industry [53] and aligns

manufacturing with customer needs, satiating client desires[59][60], which is regarded as a key aspect for any organization's competitiveness ([21][56][61]]). Manufacturing agility can improve organizational performance by generating operational efficiency and strategic competitive advantages [60]. If each product's originality or clarity of innovation is maintained, a diverse range of options stimulates customers and opens the door to increased sales, profit margins, and revenues [43][62]]. The following hypothesis is proposed based on the previous arguments:

Hypothesis H5

Mass customization ability is positively related to competitive advantage

2.8 Research Model Fig. 1 illustrates the proposed research model, the hypothesized relationship, and the equivalent which has been previously explained in the hypotheses development section.

3. Research Methodology

The main goals of this study are to see how different constructs stated by Hart (1995) affect the ability of an Indian company to mass customize products, which is necessary for competitiveness.

3.1 Design of survey instrument and its reliability The four pillars of mass customization developed by Hart 1995 were adopted as the manufacturing model based on the research gap, and a preliminary collection of several factors was generated based on literature review, experience surveys, in-depth interviews, focus groups, and critical incidents [63]. The next step was to create a questionnaire based on a literature study, with each latent variable analyzed consisting of a set of items to be evaluated. There were three sections to the questionnaire. The first component of the questionnaire covers questions about the respondents' demographics, the sort of industry in which they work, and the size of their company in terms of manpower and turnover. The next section contains questions about the respondents' perceptions of their level of MC skill. The final segment contains questions about how respondents feel about various aspects of MC. The response format was a five-point Likert scale, with values ranging from 1 to 5, with 1 indicating strong disagreement and 5 indicating strong agreement [64][65].

The questionnaire was subjected to a panel examination to ensure that it was accurate and clear [66]. This panel consisted of ten experts who were specifically briefed about the research concept and its dimensions and was finalized by engaging individually with six experts from manufacturing firms who were Managers, Vice Presidents, General Managers, Assistant General Managers, and other positions, two consultants from the field with extensive experience, and two academic experts (Ph.D. holders from prestigious universities). The expert screening process was developed in such a way that the panel of evaluators could discover items that were too identically worded [67]. The updated pool of topics was validated with a smaller group of respondents after the questionnaire was validated to ensure that all of the items were clear and understandable to the target audience [68]. The next step was scale purification, which involved using a refined and reduced scale for data collection while adhering to a sampling strategy that was adequately justified in the context of the study.

3.2 Target organizations and target respondents: Respondent lists were obtained from reputable sources such as chambers of commerce and industry, trade organizations, and alumni associations. The most important criteria, limits, and obstacles were to identify respondents with prospective expertise to address knowledge in the questionnaire from a variety of fields covered by various domains [69]. The survey was conducted in India's manufacturing and processing industries. Companies that used or were familiar with such technology were chosen as respondents.

3.3 Collection of data: To obtain responses from potential respondents, the questionnaire was distributed both offline and online. In the case of offline mode, respondents were requested to schedule an appointment ahead of time. A soft copy of the questionnaire was then emailed to them, along with a supplemental background note on mass customization, to help them better comprehend the many aspects. A face-to-face interview was used to obtain responses from the respondents. In the instance of an online survey, participants were asked to make their beneficial inputs available. The questionnaire and background note on MC were emailed to 856 respondents from India's manufacturing businesses, representing a variety of industries. The filled-in surveys were examined to see if the respondents gave significant inputs once the online and offline responses were received.

3.4 Respondent Characteristic

856 respondents from India's manufacturing enterprises, covering a variety of industries, were emailed the questionnaire and background note on MC. Once the online and offline replies were collected, the filled-in surveys were analyzed to see if the respondents provided meaningful contributions. Out of the 856 surveys distributed, 286 were completed and returned. In the surveys, missing data and outliners were examined[70]. For 10 surveys, outliners were recorded, generating 276 acceptable responses. The final response rate was 32.24 %, which was higher than the minimum of 20 % proposed by Malhotra and Grover[71] for guaranteeing the quality of the empirical research.

Sample characteristic of respondents exhibits that as per job designation, top management constituted 34.6%, middle management 42.9%, administrative staff 8.3%, technical staff 3.9%, academician 10.2%. Marketing professionals accounted for 17.3 % of the respondents, followed by production 16.9 %, procurement 15.4 %, logistics 11.4 %t, R&D 10.2 %, and project management 8.3 %. In terms of time spent in the company. 5.1% of those polled have worked for their businesses for fewer than five years. 4.3 % of respondents have worked for the company for 5 to 10 years, 23.2 % for 10 to 20 years and 49.6 % have worked for the company for more than 20 years. Respondents had a 3.9 % post-doctoral, 18.5 % Ph.D., 55.1 % postgraduate, 17.9 % graduate, and the rest diploma holders as their educational backgrounds.

The Sample characteristic of the surveyed organization consists of consumer electronics 18.5%, interiors, and decors 18.1%, automotive 14.2%, apparel, and footwear 9.8%, food 9.1%, rest were variable industries. Concerning the strength of workers, organizations with more than 1000 workers were 32.7%, 1000 to 500 was 25.6%, 200–500 was 18.5%, 100–200 was 11%, less than 100 was 12.5%. Annual turnover in crores for less than 10 was 21.7%, 10 to 50 was 15.4%, 50 to 100 was 8.5%, 100 to 500 was 17.3%, more than 500 was 35.8.

3.5 Tests for potential bias in survey data: The responses were examined for non-response bias, which might reduce response validity (Bailey, 1978). The application of t-tests to analyze non-response bias is a common strategy, assuming that late responders (e.g., second-wave replies) can be seen as non-responses of early responders (e.g., the first wave). For this study, 20 survey items were chosen at random for analysis, two groups of 50 surveys were picked at random from the first and last waves of surveys received, and the results of the two groups were compared using t-tests[72] with the help of SPSS program. Using t-tests, there were no statistically significant differences between the 20 survey questions. Although these findings do not rule out the possibility of non-response bias, they do show that non-response may not be a problem if late responders represent the views of non-respondents. As a result, scale purification and a confirmatory factor were added to the data analysis.

Because the data came from a single survey, there was a risk of common method bias [73], so Harman's single-factor test was run on the variables using SPSS and exploratory factor analysis (EFA). The findings revealed that a single component was responsible for 48.25 % of the total variance, which is less than 50%. The findings indicate that no one or general factor appeared, and it was considered that common technique bias was not a concern.

4. Analysis And Results

It is critical to ensure that the given theoretical framework is reliable and valid before testing it([74] [72]).

4.1 Reliability and validity analysis

Both EFA and CFA are used to test the concept's reliability and validity. To examine construct reliability, EFA is used to test the scales' unidimensionality, followed by Cronbach's alpha and composite reliability (CR)[74]. The correlated item–total-correlation (CITC) was calculated to do the reliability analysis. A CITC value of more than 0.30 is recommended. Table 1 illustrates the CITC. As indicated in Table 1, all six constructions had CITC values greater than 0.30[75]. As a result, the scales are determined to be internally reliable, and the construct dependability of the measurement model is not impacted.

EFA with principal component analysis and varimax rotation with Kaiser normalization is carried out[39] using SPSS. The Kaiser Meyer-Olkin value of 0.941 is higher than the suggested minimum value of 0.5 [76], indicating that the sample size is sufficient. The Bartlett Test of Sphericity, which is a measure of the multivariate normality of a set of distributions and evaluated the null hypothesis in SPSS, was used to determine the strength of the link [76]. Table 2 shows how six EFA components affect the loadings of measuring scale variables. It meets the requirement of clarifying the factors and the hypothesized model based on theory because components 1, 2,4, and 5 correspond to the four pillars of mass customization, namely Customer Sensitivity, Organizational Readiness, Competitive Environment, and Process Amenability, and components 3 and 6 correspond to Competitive Advantage and Mass customization Ability. From 0.689 to 0.886, the variable loading ranges. For each construct, a Cronbach's alpha value

was calculated, which ranged from 0.90 to 0.95 (Table 1), all of which are higher than the recommended threshold value of 0.70.[75].

Table 2
Rotated Component Matrixa

	Component					
	1	2	3	4	5	6
Create value for customer	.880	.156	.140	.113	.218	.084
Understand uniqueness of customers' needs	.840	.161	.171	.211	.200	.167
Provide ease of customer choice for decision making	.832	.162	.196	.150	.201	.082
Identify opportunities for customization	.832	.128	.160	.208	.216	.110
Incorporate customer requirement during new design process	.818	.092	.150	.164	.268	.043
Analyze customers sacrifice for unmet needs	.794	.185	.167	.220	.164	.087
Skill development of employees	.156	.865	.206	.140	.164	.132
Employees involvement in product and process roadmap	.134	.855	.173	.075	.135	.128
Training to marketing team to capture and prioritize requirements	.213	.851	.200	.134	.129	.123
Cultural change in the organization	.100	.848	.185	.178	.109	.110
Top management support and leadership building	.181	.843	.213	.129	.174	.158
Increased sales volume/ Return on sales/revenue	.189	.164	.822	.119	.094	.152
Market share growth/Reaching financial goals	.189	.264	.765	.135	.083	.128
Reduce waste through on time production	.139	.183	.758	.154	.188	.217
Acquiring new customer/Perceived customers value	.180	.138	.753	.177	.217	.190
Increased product variety	.159	.242	.753	.127	.016	.186
Market Turbulence	.178	.084	.129	.834	.202	.169
Economic uncertainty	.211	.065	.135	.792	.195	.166
Potential of competitors to react	.190	.250	.160	.742	.241	.197
Customer loyalty	.301	.214	.178	.679	.203	.218
Company credibility and position in marketplace	.217	.196	.246	.677	.313	.205
Develop marketing competence for product promotion	.250	.152	.168	.279	.765	.158
Develop production and distribution process for timely delivery	.317	.208	.121	.203	.746	.235
Develop supplier for co-design	.268	.173	.145	.295	.735	.206

	Component					
	1	2	3	4	5	6
Incorporate modularity in design, for part flexibility	.332	.149	.060	.267	.715	.217
Develop compatible process technology	.286	.176	.196	.182	.686	.188
Product can be customized on large scale	.096	.183	.174	.245	.165	.817
Product variety can be enhanced at same cost and quality	.078	.168	.192	.236	.224	.786
Product can be designed based on customers' requirements	.161	.159	.266	.211	.227	.761
Product can be delivered on stipulated time	.158	.157	.398	.154	.249	.684
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.						
a. Rotation converged in 6 iterations.						

Figure 2 shows a CFA model with the AMOS 23 program. Each item in the model is associated with a construct, and the covariance between those constructs is computed. The data were examined for skewness, kurtosis, and normality. There was no major violation found. According to the modification indices, no major changes were required for this model. The chi-square statistic to degrees of freedom (CMIN/DF) ratio, adjusted goodness of fit [AGFI], goodness-of-fit index GFI, root mean square residual [RMR], normed fit index NFI, Bentler comparative fit index [CFI], and root mean square error are all indicators of acceptable fit.[77] and the adequate fit suggested for models is shown in Table 2. It can be seen from Table 3 that all the measurement models have acceptable fit indices, and consequently signify the unidimensionality of the constructs.

Table 3
Model Fit Indicators for CFA

Indicators of Model Fit	CMIN/DF	AGFI	GFI	RMR	NFI	CFI	RMSEA
Result	1.73	0.83	0.86	0.032	0.91	0.96	0.050
Default Value	Less than 2	Greater than 0.8	Greater than 0.8	Less than 0.05	Greater than 0.9	Greater than 0.9	Less than 0.06

After the factors are extracted using EFA and the quality of fit is confirmed using CFA, validation is done in two steps. Expert opinion is used to assess content validity, and construct validity is divided into two parts: convergent validity and discriminant validity. The values of CR (Construct Reliability) and AVE (Average Value Efficiency) determine convergent validity (Average Value). The CR and AVE values should both be more than 0.7 and 0.5, with CR always being bigger than AVE[78]. Discriminant validity is determined using MSV values (Mean Shared Variance)[77]. The AVE value should always exceed the MSV value. Table 4 backs up the findings, and both convergent and discriminant validities exist.

Table 4: Assessment of Discriminant Validity and Convergent Validity

	CR	AVE	MSV	ASV	Customer Sensitivity	Process Amenability	Competitive Environment	Organizational Readiness	Mass Customization	Compititive Advantage
Customer Sensitivity	0.96	0.80	0.45	0.28	**0.89**					
Process Amenability	0.92	0.71	0.52	0.37	0.67	**0.84**				
Competitive Environment	0.91	0.66	0.52	0.37	0.59	0.72	**0.81**			
Organizational Readiness	0.95	0.81	0.27	0.25	0.45	0.50	0.52	**0.90**		
Mass_Customization	0.90	0.71	0.42	0.33	0.44	0.65	0.65	0.49	**0.84**	
Compititive_Advantage	0.90	0.66	0.41	0.30	0.45	0.5	0.56	0.55	0.64	**0.81**

4.2 Means, standard deviations, and correlations

To acquire a thorough grasp of the data, descriptive statistical analysis was used. As a result, descriptive statistics and bivariate correlation data derived from the Pearson coefficient correlation approaches have been assessed (Table 5). Table 5 reveals that the correlation coefficients for the constructs are greater than 0.40 at the 0.01 level (2-tailed), showing that they are positive and statistically significantly correlated[79]. However, because no relationship is greater than 0.70, multi-collinearity is unnecessary [79].

Table 5: Descriptive analysis and correlations

	Mean	SD	Customer Sensitivity	Process Amenability	Competitive Environment	Organizational Readiness	Mass Customization	Compititive Advantage
Customer Sensitivity	3.74	0.96	1					
Process Amenability	3.79	0.88	0.67	1				
Competitive Environment	3.80	0.79	0.59	0.70	1			
Organizational Readiness	3.87	0.89	0.45	0.50	0.52	1		
Mass_Customization	3.95	0.75	0.44	0.65	0.65	0.49	1	
Compititive_Advantage	3.88	0.72	0.45	0.50	0.56	0.55	0.64	1

4.3 Hypothesis Testing

Using AMOS 23, SEM analysis was used to analyze the associations between each pair of postulated components, as shown in Table 6. Figure 3 shows a path diagram created with the AMOS software., which portrays the results of analysis derived from the SEM. Model fit indices values shows good fit (CMIN/DF = 1.83; GFI = 0.85; AGFI = 0.83, NFI = 0.91, CFI = 0.95, RMSEA = 0.05). All these values are satisfactory for the recommended range values.

Table 6
Result of Hypothesis testing

	Hypothesis	B	C.R(β)	p-value	Supported
H1	Customer sensitivity is positively related to MC ability	-0.05	-0.096	0.33	Not Supported
H2	Process Amenability is positively related to MC ability	0.28	4.07	0.00	Supported
H3	Competitive Environment is positively related to MC ability	0.34	4.32	0.00	Supported
H4	Organizational readiness is positively related to MC ability.	0.14	3.12	0.002	Supported
H5	Mass customization ability is positively related to competitive advantage	0.69	10.23	0.00	Supported

In terms of the impact of customer sensitivity on MC ability, the SEM results do not support H1, the path coefficient is β =-.05, t = − .096, thus disagreeing with the suggestions of Hart (1995) that the customers' needs and wants, and his sacrifice for unmet needs requires to be considered by any organization before shifting from mass production to mass customization. The result is surprising, but it may be because the analysis was carried out in India where mass customization is at its nascent stage, and respondent's ability to analyze the gap between products provided and products desired by the customer gives rise to mass customization ability was crucial. As hypothesized, a significant relationship between Process Amenability and mass customization ability is observed (β = 0.28, t = 4.07, significant at p < 0.00), thus supporting H2. This concurs with the research by Hart (1995) that organizational enablers, marketing competence, supportive production and distribution team, and design aspects can enhance the mass customization ability of a firm. Hypothesis H3 is supported (β = 0.34, t = 4.32, significant at p < 0.00), acceding Hart's research theory that a competitive environment promotes mass customization. Hypothesis H4 showing Organizational Readiness leads to mass customization ability is supported (β = 0.14, t = 3.12, significant at p < 0.002), harmonizing with research by Hart (1995) that organizations need to identify the fit between business opportunity and organizations ability to capitalize on this opportunity before venturing into mass customization. Finally, H5 is supported (β = 0.69, t = 10.23, significant at p < 0.000), emphasizing that MC-capable manufacturing plants may dynamically modify their resource/skill mix to adapt to individual client demands, gaining a competitive advantage [13].

5. Results And Discussion

To meet customer demand in a certain period, a manufacturing company must choose the best acceptable product configuration from a wide range of options to achieve effective MC, which in turn relies on the firm's capacity to effectively grasp client wants and obtain the necessary mix and quantity of components for timely assembly of the needed product configuration. The goal of this study is to categorize, consolidate, and validate important components that influence the ability of Indian manufacturing companies to integrate mass customization. Hart's (1995)'s four pillars of mass customization were used to identify constructs, which are then followed by a systematic literature review to identify measurement items. The study used this information to describe the links between mass customization and competitive advantage, as well as give empirical evidence for the proposed research technique.

The disruption caused by COVID-19 on manufacturing has a considerable influence on operational, social, and financial sectors, as well as posing challenges to organizations attempting to accelerate the change of global value distribution models, effectively halting many Indian industries. The manufacturing sector in India is now at a crossroads with unprecedented consequences for manufacturers and supply chains[41]. A new method is required to limit the impact of COVID-19 and rethink risk management and contingency plans. This empirical model of mass customization can provide manufacturers with a solution to the pressing issues that must be addressed to make the business as stable as possible. This strategy will not only improve resilience, protect operations, and support people during the crisis, but it will also help businesses maintain a competitive advantage and accelerate growth after the economy recovers.

6. Managerial Implications

The practical goal of the research is to provide strategic instructions to top-level manufacturing executives to encourage mass customization for business excellence. According to the findings of the study, the competitive environment has a significant impact on mass customization, which is consistent with Hart's (1995) research findings that organizations should shift from mass production to mass customization only when market turbulence occurs, resulting in homogeneous versus heterogeneous customer demand. However, the first-mover advantage can only be guaranteed if there is customer loyalty and a good reputation in the market. Because of the turbulence that has disrupted the mass market, mass customization should be regarded as an organizational approach. Firms should view market volatility as an opportunity rather than a hindrance or a threat to which they should escape [1].

Once the organization had identified its potential to venture into mass customization, it needs to strengthen the other three pillars simultaneously. Customer sensitivity that identifies the uniqueness of customer needs and sacrifices for unmet needs should be deciding factor for the type of mass-customized product, which should cogitate the voice of the customer during the new design process. The other pillar Process Amenability needs to empower production, process, distribution, vendor for co-

development, and marketing team to be ‘market ready’ for mass customization. The fourth pillar, requires firstly, top management involvement (highest factor loading) and employee empowerment to ensure a cultural change, followed by skill development of employees for the successful attainment of mass customization goals.

The above guidelines provide a framework and guidelines for managers willing to implement mass customization.

7. Limitations Of The Study And Future Research Direction

There were several limitations, as with any empirical study, that necessitated additional research. The study is both national and industrial. Future applications should test this model in another country to validate it across other markets. Second, the study focuses on the manufacturing sectors. In the future, a comparative cross-industry study could be conducted to evaluate the model proposed in this study in other industries. The model can likewise be put to the test in the service sector.

Future research could include elements not included in this study, such as financial concerns. This framework is best suited for companies with a solid technical foundation. A comparable framework for MSMEs and start-ups may be investigated for the use of mass customization in a variety of businesses. Furthermore, the aforementioned concept was put to the test for mass customization to gain a competitive advantage. It is possible to test the same model to see if it is profitable for a business.

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3. **Availability of data and material** (Data will be made available as desired by journal)
4. **Code availability** (Not applicable)
5. **Ethics approval (**The authors have abided by the ethics policies of the journal**)**
6. **Consent to participate (**Author and co-authors consent to participate**)**
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Figures

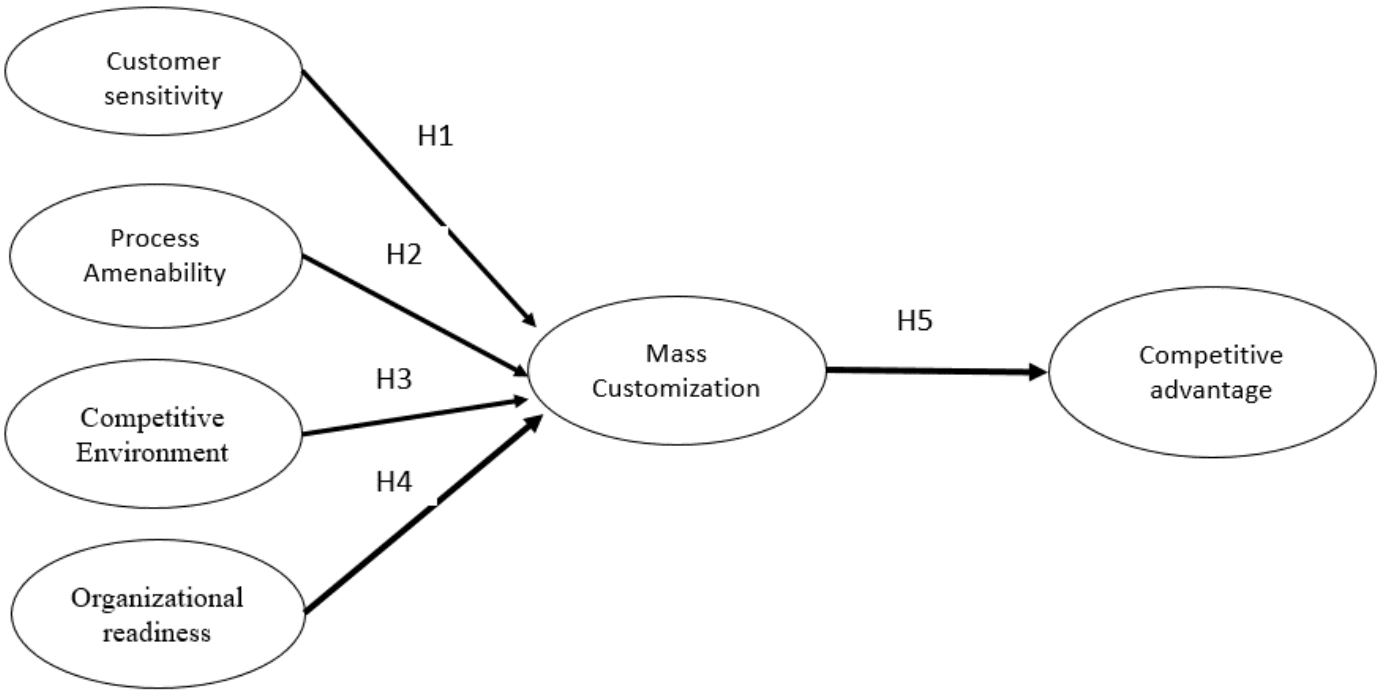

Figure 1

Research Framework

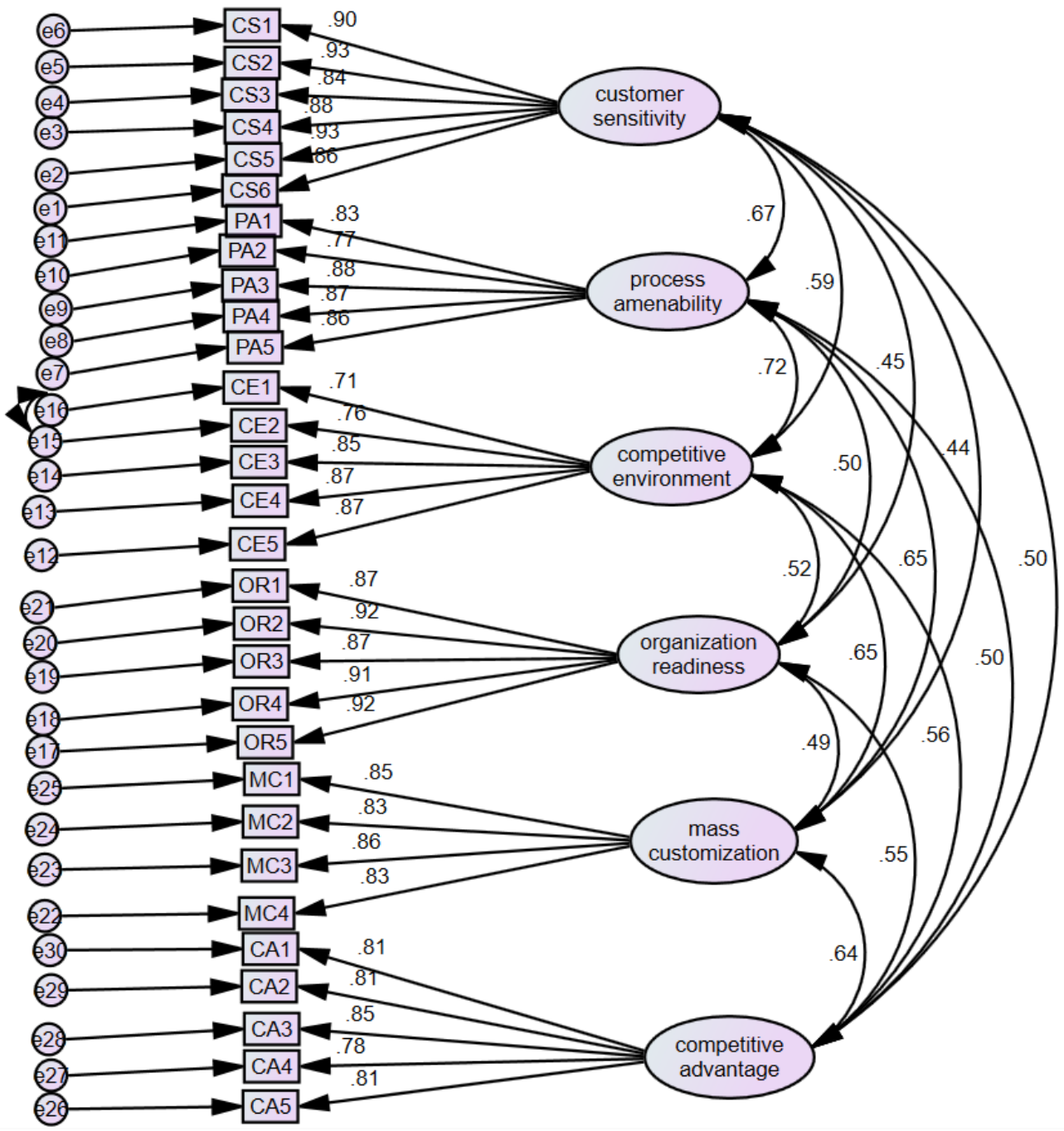

Figure 2

Path diagram showing the regression weights and the correlation between the Constructs

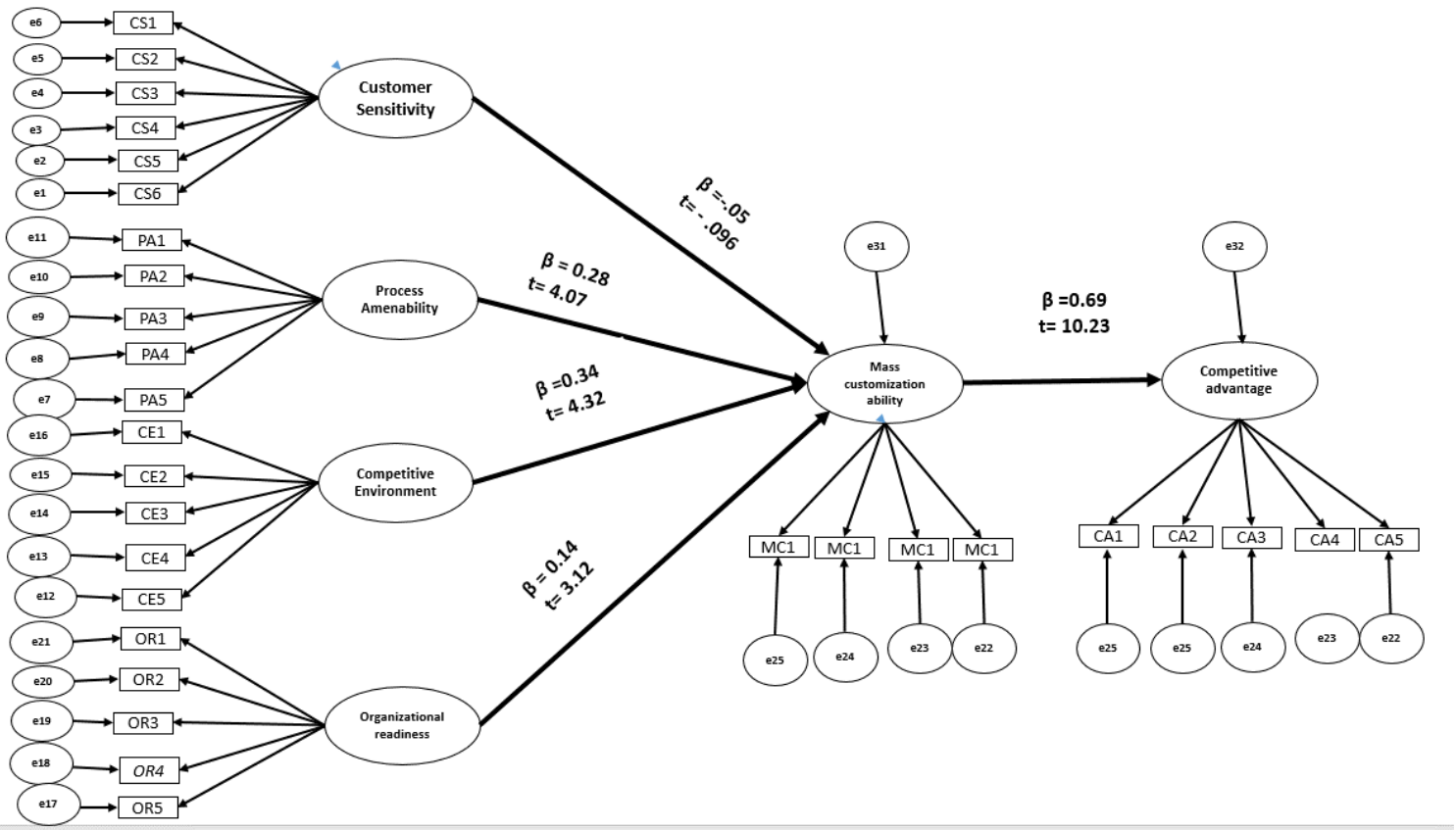

Figure 3

Path Diagram of Structural Equation Model

Supplementary Files

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